REPORT RESUMES

ED 011 860 SE 001 661

COURSE AND CURRICULUM IMPROVEMENT PROFECTS--MATHEMATICS, SCIENCE, ENGINEERING.

BY- FONTAINE, THOMAS D.

NATIONAL SCIENCE FOUNDATION, WASHINGTON, D.C.
REPORT NUMBER NSF-66-22 PUB DATE SEP 66
EDRS PRICE MF-$0.18 HC-$5.00 125P.

DESCRIPTORS- *COLLEGE SCIENCE, *CURRICULUM DEVELOPMENT, *ELEMENTARY SCHOOL SCIENCE, *SCIENCE COURSE IMPROVEMENT PROJECT, *SECONDARY SCHOOL SCIENCE, BIOLOGY, CHEMISTRY, COLLEGE MATHEMATICS, ENGINEERING, ELEMENTARY SCHOOL MATHEMATICS, EARTH SCIENCE, PSYCHOLOGY, PHYSICS, SECONDARY SCHOOL MATHEMATICS, SOCIAL SCIENCES, NATIONAL SCIENCE FOUNDATION, EARTH SCIENCE CURRICULUM PROJECT, BIOLOGICAL SCIENCES CURRICULUM STUDY, CHEMICAL BOND APPROACH

ELEMENTARY, SECONDARY, AND COLLEGE LEVEL SCIENCE COURSE IMPROVEMENT PROJECTS ARE DESCRIBED. INDIVIDUAL PROJECTS ARE CLASSIFIED ACCORDING TO INSTITUTIONAL LEVEL AND ACADEMIC DISCIPLINE. MANY OF THE PROJECTS REPRESENT COMPLETE EDUCATIONAL PROGRAMS AND INCLUDE SUCH MATERIALS AS STUDENT TEXTBOOKS, LABORATORY MANUALS, SUPPLEMENTARY READINGS, TEACHER GUIDES, FILMS, AND OTHER AUDIOVISUAL AIDS. OTHERS ARE NARROWER IN SCOPE AND INVOLVE SUCH ACTIVITIES AS THE DEVELOPMENT OF VISUAL AIDS, LABORATORY EXERCISES, AND DEMONSTRATION EQUIPMENT. INFORMATION CONCERNING THE PROJECTS INCLUDES (1) THE PROJECT TITLE, (2) THE NAME OF THE PROJECT DIRECTOR, (3) THE RATIONALE OF THE PROGRAM, (4) A BRIEF HISTORY OF ITS DEVELOPMENT INCLUDING ITS CURRENT STATUS AND ANTICIPATED FUTURE ACTIVITIES, (5) A LIST OF MATERIALS THAT HAVE BEEN PREPARED BY THE PROJECT STAFF, AND (6) BIBLIOGRAPHIES. THIS DOCUMENT IS AVAILABLE FROM THE SUPERINTENDENT OF DOCUMENTS, U.S. GOVERNMENT PRINTING OFFICE, WASHINGTON, D.C. 20402, FOR $0.65. (AG)

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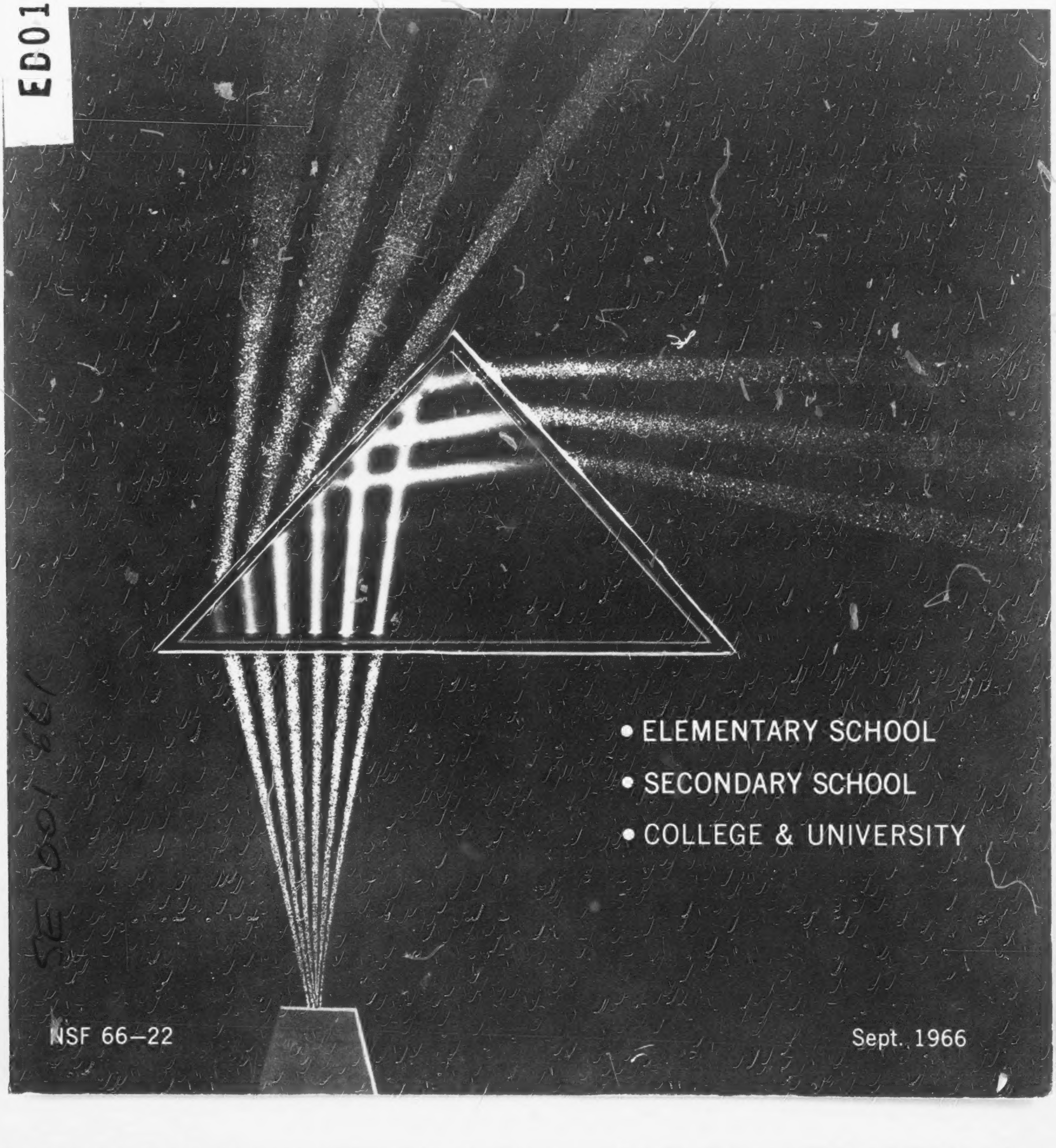

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Foreword

IN VERY MANY WAYS the plans and expectations of Americans, and indeed of people everywhere, depend upon a strong and growing science and technology. The increasing importance of science to our Nation and the world creates pressing educational demands. Literacy in science is becoming essential for all citizens who wish to comprehend the world they live and work in and to participate in the increasing number of local and national decisions, some of gravest import, that require an understanding of science. Further, more and more students must be attracted to scientific and technical pursuits, and these students must be prepared to work with increasingly sophisticated ideas and techniques.

Very practical considerations compel us to give attention to the strengthening of science education. But there is another aspect of the matter, namely, the principle held by those taking part in the reform of science education that more emphasis should be given to disciplined, creative, intellectual activity as a noble enterprise and to intellectual achievement as a worthy end in itself. There is a desire to allow each student to experience some of the excitement, beauty, and intellectual satisfaction that scientific pursuits afford. Similar movements also aimed at giving the student experiences and points of view heretofore largely limited to professionals in a field are beginning to go forward in the humanities and the arts. These experiences, it is hoped, will lead many to enter scholarly professions and others to adopt some of the scholarly and artistic modes of thought in their work and their avocations.

Good teachers and good schools have always worked individually to give students the best educational fare they could. Nowadays, however, the task of bringing the best that has been thought to all students—in ways appropriate to their varied interests, abilities, and future lives—requires new strategy and tactics. We live in an age of explosive growth of knowledge. More scientific and technological discoveries have been made in the past fifteen years than in all previous recorded time. Powerful new insights are being gained into the fundamental structure of major areas of inquiry. Moreover, traditional assumptions about what students at given levels of development can learn are increasingly found to be misleading in many ways. Finally, society can no longer afford to wait for a generation or more for new knowledge to make its gradual way into school and college programs.

In the last few years, mathematicians, scientists, engineers, and educators have taken up these new educational challenges with great vigor. Working together, and aided by increasing public and private support for educational research and development, they have undertaken a number of fresh approaches to the improvement of school instruction in mathematics and science. In colleges and universities, research scientists have been taking an increasing interest in undergraduate instruction. The aim has been to see that instruction presents contemporary knowledge as well as contemporary viewpoints on knowledge established earlier. In many cases it has seemed best to start anew rather than merely to patch up older courses. A distinctive feature of many projects is the effort made to go beyond the presentation of what is known and to provide students with experience in the processes by which new facts, principles, and techniques are developed.

The purpose of the present edition of this booklet, as of the earlier editions, is to provide a readily available guide to curriculum improvement projects supported by the National Science Foundation. Decisions on what to teach remain, in the healthy American tradition, the exclusive responsibility of individual schools and teachers. The National Science Foundation does not recommend the adoption of any specific book, film, piece of apparatus, course, or curriculum. It is hoped, however, that the products of these projects will prove to merit serious consideration by all concerned with education at every level from primary to graduate.

THOMAS D. FONTAINE
Associate Director (Education)

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Introduction

The Science Course Improvement Programs of the National Science Foundation have as their objective the improvement of the substance of courses in mathematics, science, and engineering at all educational levels. Outstanding scientists, mathematicians, and engineers take responsibility for preparing new and innovative materials which present modern science in challenging but comprehensible form. Course improvement activities include a wide diversity of projects ranging from curriculum conferences through development of new or improved instructional apparatus to the production of complete courses that may include new laboratory experiments, laboratory guides, educational films, and teachers' guides, as well as textbook materials. Foundation support is limited to the design and development of these new materials. No grant funds may be expended for promotional purposes, and the final products must gain acceptance on their own merits.

This publication contains descriptions of most projects supported by the Science Course Improvement Programs of the Foundation prior to May 1966 and thus replaces two earlier NSF publications (NSF 63-15 and NSF 64-8, *Science Course Improvement Projects*). The project descriptions are taken from material supplied by the respective project directors and include the title of the project; the name of the project director; the director's institution; the grantee, if different from the director's institution; and the period covered by Foundation support.

The projects are classified by institutional levels—elementary and secondary school or college and university — and by academic discipline where appropriate. Within each discipline, the projects are arranged in order of decreasing breadth of interest—from projects of discipline-wide interest through projects concerned with a particular course to projects dealing with the development of a specific instrument or device. Since many projects are of interest to more than one discipline, a partial cross-reference is provided at the beginning of each section. Many readers will find it profitable to spend some time looking through the projects of related areas as well as reviewing the more detailed study of the projects in the discipline in which they have a primary interest.

In addition, the results of many projects have been translated or modified for use in foreign countries. A list of such translations or adaptations can be obtained from the Foundation. The appendix gives a list of commercial suppliers and publishers who are producing and distributing materials developed under the various programs. A source of additional information is given in most project descriptions. *Inquiries for further information about individual projects should be addressed to the project director or other sources cited and not to the National Science Foundation.*

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I. General Projects

For additional projects related to this section see also:
16. Conferences on Science Curriculum Planning.

1. AAAS Commission on Science Education. LEONARD RIESER (Chairman), Dean of Faculty, Dartmouth College; JOHN R. MAYOR (Project Director), American Association for the Advancement of Science, 1515 Massachusetts Avenue, N.W., Washington, D.C. 20005. (Grantee: American Association for the Advancement of Science.) (1962– .)

The Commission on Science Education, established in 1962, includes scientists recognized for their achievements in scientific research, school administrators, science education specialists, and teachers in the schools. The activities of the Commission, which has assumed a broad responsibility for the improvement of science education at all levels, include dissemination of information on course content development in science; work with other groups in the improvement of science education; and, where possible, promotion of cooperation among projects; development of services; and sponsorship of studies which might be useful to other science curriculum projects and to the schools. The Commission has prepared a statement of purposes and objectives of science instruction in the elementary schools, a review of research in science education, and two monographs, one on the strategy of evaluation and the other on the psychological bases of the experimental science program for elementary schools developed under the sponsorship of the Commission.

In the summer of 1965 the Commission conducted an eight-week writing session of 40 scientists and teachers which prepared the third experimental edition of *Science—A Process Approach*, including teacher text materials for use in grades K-6 and an additional *Commentary for Teachers*. A kit of teaching aids has been prepared for each grade level. The major thrust of the exercises is in developing children's skills and competencies (observation, communication, classification, measurement, inference, prediction, recognition of number relations, recognition of space/time relations) needed for the study of science. The exercises for the intermediate grades are developed in terms of "integrated" processes including formulation of hypotheses, making operational definitions, formulation of models, control and manipulation of variables, interpretation of data, and experimentation. The materials are being tried out during the 1965-66 school year by teachers in 14 centers.

Science—A Process Approach, Third Experimental Edition in seven parts for use in grades K-6; "Review of Research in Science Education," *Journal of Research in Science Teaching* 1 (3), (1963); *Newsletter* of the Commission on Science Education, published quarterly and distributed without charge; *The Psychological Bases of Science—A Process Approach*, and *A Design for Evaluation*, paperback monographs. An annual review of course content projects in science and mathematics is prepared by the Science Teaching Center of the University of Maryland working in cooperation with the Commission.

Further information may be obtained from the project director.

2. Minnesota School Mathematics and Science Teaching Project (MINNEMAST). *(Elementary, Secondary, College)* JAMES H. WERNTZ, JR., Minnesota School Mathematics and Science Center, University of Minnesota, Minneapolis, Minn. 55455. (1961– .)

The main purpose of the project is to produce a coordinated mathematics and science curriculum for grades K-9, with appropriate teacher-training materials. At the same time attention will be given to development of evaluation procedures for course material and research in children's learning of mathematics and science.

The mathematics materials are based on three structures children learn to deal with: the real number system, space with a measure, and Euclidean space. A Cartesian coordinate system and graphical algorithms for numerical operations provide the main focus for children's materials in grades K-6. The science materials for primary grades center about operations a scientist does (observing, describing, classifying, measuring, forming hypotheses, deducing predictions, testing). The main focus of later science materials is the study of invariance and change under different physical transformations in physical and biological systems. The courses are designed to take about half an hour each, daily, in the primary grades. They are prepared for average elementary-school children with supplementary enrichment activities for gifted children. Additional material is in preparation for the culturally disadvantaged. At present, mathematics materials for grades K-3 and part of 4 have been written and are undergoing tests and revision. Science courses for grades K and 1 are available in revised forms, and drafts of materials for grade 2 are undergoing preliminary tests and revisions. Courses for children are prepared as completely developed teacher's lesson plans incorporating worksheets and other student material. Participating teachers are also issued MINNEMAST-developed teaching devices, illustrative aids and kits of science materials. A college mathematics course for liberal arts and education majors contains an integrated treatment of topics in arithmetic, algebra, and geometry. Completed in revised form, it is undergoing testing.

All course materials are supplied for teaching and evaluation to cooperating schools through ten MINNEMAST trial centers. Some are available in limited quantities to other schools at cost.

An Overview of Project MINNEMAST: Project Goals and Summaries of Course Materials (1965-66).

MINNEMAST Center Reports, published quarterly, available on request.

P. C. Rosenbloom, "Implications for the Colleges of the New School Programs," *American Mathematical Monthly* 69, 255-59 (1962).

P. C. Rosenbloom, "Mathematics, K-14," *Educational Leadership* 19, 359-63 (1962).

P. C. Rosenbloom, "The Minnesota Mathematics and Science Teaching Project," *Journal of Research in Science Teaching* 1, 276-80 (1963).

Further information may be obtained from the project director.

3. Study on Fundamental Processes in Education. R. M. WHALEY, Advisory Board on Education, National Academy of Sciences-National Research Council. (Present address: University of Missouri, Kansas City, Mo. 64110.) (1959)

J. S. Bruner, *The Process of Education*, Harvard University Press (1962).

4. Study Conference on Evaluation. J. THOMAS HASTINGS, Center for Instructional Research and Curriculum Evaluation (CIRCE), University of Illinois, Education Building, Urbana, Ill. 61803. (1963–1964)

L. J. Cronbach, "Evaluation for Course Content Improvement," *Teachers College Record* 64, 672 (1963).

Further information and a report of the conference are available from the project director.

5. "Horizons of Science" Films. *(Secondary, College)* JOHN S. HOLLISTER, Educational Testing Service, Princeton, N. J. 08540. (1959–1960)

The "Horizons of Science" film program consists of ten 20-minute, 16mm, sound-color films designed to communicate the excitement of science and an understanding of the significance of a number of current scientific projects. In effect, the films allow an audience to take actual field trips with prominent scientists and to hear them explain their work and its importance. The films are:

Visual Perception, with psychologist Hadley Cantril; *The Worlds of Dr. Vishniac*, with microbiologist Roman Vishniac; *Exploring the Edge of Space*, with aeronautical engineer Otto C. Winzen; *"Thinking" Machines*, with Claude Shannon, Alex Bernstein, and Leon Harmon; *The Mathematician and the River*, with mathematician Eugene Isaacson; *New Lives for Old*, with anthropologist Margaret Mead; *Project "Mohole,"* of films of the U. S. oceanographic expedition surveying possible drilling sites; *The Realm of the Galaxies*, with astronomer Allan R. Sandage; *The Flow of Life*, with Benjamin Zweifach and others; and *Neutrons and the Heart of Matter*, with the late Donald J. Hughes.

Films, study guides, a general descriptive brochure, and progress reports are available from the project director.

II. Elementary and Secondary School Projects

A. Multidisciplinary

For additional projects related to this section see also:

3. Study on Fundamental Processes in Education.
4. Study Conference on Evaluation.
5. "Horizons of Science" Films.

6. Science Curriculum Improvement Study. ROBERT KARPLUS, Department of Physics, University of California, Berkeley, Calif. 94720. (1959–)

The Study is exploring a concept of science education based on communicating scientific literacy. The large-scale organization of the curriculum is to be determined by the structure of science, by the increasing maturity of the pupils, and by the pupils' preconceptions. Single lessons or groups of lessons are designed to lead students to discover the significance of certain scientific concepts. These lessons include individual pupil manipulation and experimentation, group activities, and class-wide demonstrations and discussion; they will be planned so that a secure connection is achieved between the pupils' preconceptions or common-sense attitudes and the concepts that embody the modern scientific point of view. Concepts include interactions between objects as causes of phenomena, physical systems (including living organisms), relativity of position and motion, equilibrium, entropy, and organic evolution.

The Study is also considering the significance of the teacher's attitude during a science lesson. It is important that the scientific concepts not be introduced in an authoritarian fashion, but rather as an aid to pupils to achieve a better understanding or explanation of phenomena they have observed. If such instruction is to succeed, the curriculum-maker and teacher have an obligation to furnish evidence that will be truly convincing and acceptable to the pupil. A K-6 program is now under development and classroom trial. The program is based on earlier explorations which have developed effective teaching procedures and at the same time defined the pupils' ability to deal with abstractions.

The following experimental editions are available from the Science Curriculum Improvement Study, University of California, Berkeley:

Material Objects, Interaction and Systems, Relativity of Position and Motion, Variation and Measurement, Solutions, Temperature, The Theoretical Background of the Science Curriculum Study (R. Karplus).

Science Curriculum Improvement Study *Newsletter.*

J. M. Atkin and R. Karplus, "Discovery or Invention?" *The Science Teacher* 29, 45 (1962).

R. Karplus, "Teaching Physics in the Elementary Grades," *Physics Today* 17, 34-38 (1964).

R. Karplus, "The Science Curriculum Improvement Study—Report to The Piaget Conference," *Journal of Research in Science Teaching* 2, 236-240 (1964).

R. Karplus, "The Science Curriculum Impovement Study," *Journal of Research in Science Teaching* 2, 293-303 (1964).

R. Karplus, "One Physicist Experiments with Science Education," *American Journal of Physics* 32, 837-839 (1964).

H. D. Thier and R. Karplus, "The Science Curriculum Improvement Study," Science Supplement to *The Instructor* 74, 43-84 (1965).

H. D. Thier, "The Involvement of Children in the Science Program," *Science and Children* 2, 19-22 (1965).

H. D. Thier, "Use Rock, Blocks, and 'Structure' to Teach Concepts of Science," *Professional Growth for Teachers*, K-3, Elementary School Edition (1965).

For information about subsequent reports write Herbert D. Thier, Science Curriculum Improvement Study.

7. Elementary Science Study. CHARLES WALCOTT, Educational Services Incorporated, 55 Chapel Street, Newton, Mass. 02158. (1962–)

With the broad range of the sciences to draw upon and with the conviction that building of a structured curriculum is best considered after a long and varied experience with materials placed in the hands of children in classrooms, the work of the project has been concentrated on the development of many diverse "units." The diversity is in the choice of topics, in the teaching styles implied in the guides, in the physical materials, and in the age levels for which the materials are suitable.

The development of units includes a period of careful classroom trial, observation, criticism, and revision. Since the emphasis of the project's work is to encourage children to work individually and independently, to devise experiments, and to direct their questions to the materials, there is very little written material addressed directly to children. Each unit listed below has a teachers' guide, some have worksheets or photographs, and some have films.

1. *Sampler Editions,* available from Houghton Mifflin Company include: *Small Things, Gases and "Airs", Kitchen Physics, Growing Seeds,* and *Behavior of Mealworms.* Since the work of the project represents a departure for many teachers from accustomed work in science, the project requires the purchase of an inspection carton ($20) prior to releasing teaching quantities for any of these five units. A selection of equipment sufficient to do most of the experiments in each of the units is included in teacher's guides, photographs, worksheets, film fliers, and other forms. In addition, the carton contains a description of the history of work of the project in detail and several issues of the ESS *Newsletter.*

2. *Trial Teaching Editions,* a limited number of copies of which are available free of charge from Elementary Science Study, include: *Light and Shadows, Mirror Cards, Desert Animals in the Classroom, Bones, Batteries and Bulbs, Melting Ice Cubes,* and *Changes.*

3. *Films* (16mm, sound), Houghton Mifflin Company: *Gases and "Airs" in the Classroom,* and *Paramecium, Euglena, and Amoeba.*

4. *Film Loops* (8mm silent-color, 3 to 4 min., in cartridge, for use with Technicolor projector). Available only in conjunction with unit materials (see 1 above) from Houghton Mifflin Company. *Gases and "Airs", Kitchen Physics, Growing Seeds, Small Things,* and *Microgardening.*

D. Hawkins, "Laboratory Science in Elementary Schools," *American Journal of Physics* 32, 839-842 (1964).

D. Hawkins, "Messing About in Science," *Science and Children* 2 (5), (1965), National Science Teachers Association, Washington, D. C. 20036.*

P. Morrison, "The Curricular Triangle and Its Style," *ESI Quarterly Report,* Summer-Fall 1964, Educational Services Incorporated, 55 Chapel Street, Newton, Mass. 02158.*

P. Morrison, "Experimenters in the Schoolroom," *Science* 138, 1307-1310 (1962), American Association for the Advancement of Science, Washington, D. C. 20005.

P. Morrison and C. Walcott, "Enlightened Opportunism: An Informal Account of the Elementary Science Summer Study of 1962," *Journal of Research in Science Teaching* 1, 48-53 (1963).

Mary D. Nichols, "Show-Me Science, Learning by Experiment," *Cornell Alumni News,* Ithaca, N.Y. (January 1964).

B. Nichols, "Elementary Science Study—Two Years Later," *Journal of Research in Science Teaching* 2, 288-292 (1964).*

Emily L. Richard, "Ideas Unlimited for Child Scientists," *Wellesley Alumnae Magazine* (January 1965).*

Alma S. Wittlin, "Scientific Literacy Begins in the Elementary School," *Science Education* 47 (4), (1963).

The project publishes a bimonthly Newsletter and makes a general mailing of associated materials from time to time. Names can be added to the mailing list on request to the project director.

*Requests for single copies may be addressed to the project director, Elementary Science Study.

8. School Science Curriculum Project (SSCP). Richard F. P. Salinger, College of Education, University of Illinois, Urbana, Ill. 61803. (1963–)

The project is designed to develop and prepare teaching materials in all areas of science for use in the elementary and junior high school. The operative principle or criterion is to select materials and methods which, in the judgment of competent personnel, will provide early and continuing experiences for rational analysis through an understanding of fundamental ideas and techniques. Consistent with the view that no single method or discipline exists which is best suited to a new curriculum design, the project depends considerably on the assistance of professional advisors in all areas of competency. Study groups composed of scientists, educators, and teachers met and initiated the preparation of materials in the general areas of animal behavior, animal and plant metabolism, mapping, motion and energy, introductory earth sciences, kinematics and introductory dynamics of fluid flow of water and air, change of state, wave behavior, classification principles, communication, ecology, evolution, etc. Currently, these sequences are being extended, and others are being undertaken. In addition, the project is developing associated apparatus, demonstration models, and a limited number of films.

During the summer, the project also holds teacher-orientation sessions for personnel from trial centers. These nationwide centers provide feedback data for evaluation and improvement of preliminary materials. At present the project does not endorse the materials for extended use or trial except at the trial centers since considerable revision and evaluations will be made before extensive distribution to schools. Generally, a given unit can be used at several different levels and may vary in length from four to eight weeks. The first preliminary versions at the elementary and junior high school levels were tested by about 17 trial centers in fall 1965. The following units for grades 5-9 are to be available by fall 1966: *Photographs and Pendulums, Beans and Biology, Control and Feedback, Matter and Electricity*, and *Running Water*.

SSCP *Newsletters,* May 1965, June 1964; SSCP *Summer Study Report* (1964).

"School Science Curriculum," American Association for the Advancement of Science, *Science Education News* (December 1964).

J. H. Shea, "School Science Curriculum Project," *Geology Teachers' Newsletter* 1 (2), (1964).

Further information may be obtained from the project director.

9. Elementary School Science Project. HERBERT L. MASON, Department of Botany, University of California, Berkeley, Calif. 94720. (1959–1965)

A group of scientists at the University of California, Berkeley, have created some materials for the elementary school curriculum. All materials have been tried in public schools of the area, utilizing regular teachers and students. The materials cover a wide range of areas of science.

A unit on *Coordinates* for grade 2, including a work book for pupils and a teachers' manual in four parts, is completed and available. Part I, *What Am I?* of a unit on anatomy is completed; Part II, *The Skeleto-Muscular System* is in press; Part III, *The Nervous System* and Part IV, *Metabolism* are under development. Part I, *Principles of Concealing Coloration in Animals* is in press; other parts, *Animal Behavior, Population Dynamics,* and *Natural Selection,* are under development. The first series on *Botany,* which is in press, consists of 12 short parts: (1) Living Things, (2) The Structure of Seeds, (3) The Germination of Seeds, (4) The Seedling Plant and Its Parts, (5) Growth in Length and Girth, (6) Leaves and Their Variation, (7) Stems and Buds and Their Variation, (8) Roots and their Variation, (9) The Flower, (10) Variation in Flowers, (11) Pollenation and Fertilization, and (12) A Resumé of the Kinds of Plants. These may be handled as separate units or grouped to suit the teacher's special facility.

Other units include *Paleontology* (in press), a unit in *Chemistry* which is under development, and units planned on *Wave Motion* and *Genetics.* For additional information write the project director.

10. Elementary School Science Project. JOHN K. WOOD, Department of Physics, Utah State University, Logan, Utah 84321. (1962–1966)

This project is developing a series of lessons in biological and physical science for grades K-2 designed to reveal some of the basic unifying ideas of science through investigation of everyday experiences of the child. Through puzzles and comparisons, pupils identify differences or changes. They observe such phenomena as stretching a spring, vibrating a tuning fork, or lighting a lamp with electricity. Attention is focused on the objects and the changes which take place in them. The child learns that interactions of objects are not isolated and unique, but are related to events which they have observed at other times. Acoustical interactions, for example, involve vibrating objects whether they are tuning forks or mother's vocal chords. A spiral type of approach is used with many experiments repeated in several different units, each time emphasizing a different aspect of the problem. Lessons are being tried this year in kindergarten and first-grade classes, including a general study of physical systems and the interaction of objects in a system, and an exemplification of these through activities with biological phenomena. Other lessons now in preparation and trial concern animals in favorable and unfavorable environments, and animal care. Second-grade lessons undergoing revision include units on symmetry, time, force, and sound.

Materials available include a trial edition of the teachers' manual for *Science for First Grade,* price $1.50; specimen set of a non-reading *Concept Prerequisite and Development Test,* $1.00; and some "protoscience" preliminary units for kindergarten, as well as preliminary units in biology for first and second grades.

A. L. Braswell, "Science for First Grade," *Science and Children* 2 (5), 10-13 (1965).

J. K. Wood, "Elementary Science in the First Grade," *American Journal of Physics* 32, 830-831 (1964).

A periodic newsletter and further information are available on request to the project director.

11. Quantitative Approach in Elementary School Science. CLIFFORD E. SWARTZ, Department of Physics, State University of New York at Stony Brook, Stony Brook, N. Y. 11790. (1963–1965)

The theme of this project's approach is the use of quantitative and functional relationships in the investigation of natural phenomena. During the summer of 1964, project personnel prepared student worksheets, teachers' guides, and teachers' reports in a variety of subjects for each of three age levels. The following criteria have been established: (1) the average elementary school teacher should be able to teach the materials with no special training, (2) each phase of the work should revolve around a measurement to be performed by the individual student, (3) the project must not entail large amounts of money or unwieldy blocks of time for students or teachers.

Sixty-seven units have been produced and tried in three school districts. The units are distributed from grades 1-6 and provide examples of quantitative treatment of all the standard natural science topics.

A paper on the assumptions and guidelines for the project, some sample units, and an analysis of the school trials may be obtained by writing to the project director.

12. Elementary-School Science Project. J. MYRON ATKIN, Department of Elementary Education, and STANLEY P. WYATT, JR., Department of Astronomy, University of Illinois, Urbana, Ill. 61803. (1960–)

Project activity has centered on astronomy. The professional astronomers, science education specialists and classroom teachers who make up the project staff are guided by two principles: (1) Whatever science is taught to children should be sound, (2) What is taught should reflect the essential structure of the subject. By structure is meant the relatively few, but pervasive, concepts that hold the subject together and help the student make an entity of his own of what otherwise is solely a collection of disparate facts. Astronomy is a prime example of an interdisciplinary field in the physical sciences, and basic astronomical concepts rely heavily on mathematics, physics, and chemistry. Each summer since 1961 has been devoted to the development of certain major conceptual themes reflected in a series of six books for children, grades 5-8, plus accompanying teachers' guides. During the school year following each writing conference, the new materials are field tested in over 200 classrooms across the country. Evaluation of project material is obtained from cooperating teachers in writing and through interviews, from project staff who visit classrooms where the books are being tested, and from written tests administered to the children. Subsequent revisions are based on this feedback. Considerable evaluation effort is devoted to higher mental processes, cognitive preference, and attitudinal changes.

The books and their senior authors are: H. Albers, *Charting the Universe*, 3rd ed.; S. P. Wyatt, Jr., *The Universe in Motion*, 2nd ed.; S. P. Wyatt, Jr., *Gravitation*, 3rd ed.; B. F. Peery, *The Message of Starlight*, 2nd ed.; K. Kaufmanis, *The Life Story of a Star*, 1st ed.; G. Reaves, *Galaxies and the Universe*, 1st ed.

J. M. Atkin, "Teaching Concepts of Modern Astronomy to Elementary School Children," *Science Education* 45, 54-58 (1961).

J. M. Atkin, "The University of Illinois Elementary School Science Project," *Elementary School Science Bulletin* No. 66 (1961).

J. M. Atkin and R. Karplus, "Discovery or Invention?" *Science Teacher* 29 (5), 45 (1962).

For additional information write to the project director.

13. Secondary School Science Project. FREDERICK L. FERRIS, JR., Green Hall, Princeton University, Princeton, N. J. 08540. (1963–)

Time, Space, and Matter: Investigating the Physical World, has been under development and intensive tryout in secondary schools since 1963. The course consists of a series of interrelated, sequential investigations conducted by students who, through their own direct observation, inference, and experimentation, arrive at fundamental conclusions about principles governing the development and nature of the physical world. With the teacher as a guide and critic, students explore many basic ideas of physics, chemistry, mathematics, and geology without concern for the particular discipline. The course emphasizes individual accomplishment by continuously involving the teacher and student in activities that encourage understanding of some of the ways in which scientists learn about the nature of the physical world. Students construct a continuous record of their progress from their own observations, interpretations, and conclusions. This activity, carried on in class and at home, is supported by illustrated investigative booklets, a paperbound reading series composed of selections from scientific authorities, a student laboratory kit, inexpensive and common supplies, and equipment designed to be explicit in their usefulness as investigative aids.

During the 1965-66 academic year, a number of new teachers, who received no formal orientation or institute training, are teaching the course for the first time. It is hoped hat the teachers' experiences in using course description books, teacher folios, recordings, and taped lectures by university scientists will indicate whether or not the usual cost and time for teacher training can be reduced. Preliminary work has begun with a major educational research agency to develop tests that will be consistent with the learning experience indicated in feedback from test schools.

All materials produced are for the present limited to use in test schools located in ten areas of the United States and Europe. Further information on Time, Space, and Matter may be found in *American Scientist* (June 1965); *Curriculum Report* of the National Association of Secondary School Principals (May 1965); and *The Long Road to College: A Summer of Opportunity, Special Report of the Rockefeller Foundation* (Spring 1965). Revised course materials will be made available through commercial publication, probably in 1967.

Current progress reports and a course description book may be obtained from the project director.

14. Physical Science Study Committee—Introductory Physical Science. URI HABER-SCHAIM, Educational Services Incorporated, 55 Chapel Street, Newton, Mass. 02158. (1963–)

The objective is to prepare a course in physical science for the ninth grade. Eleven chapters of the preliminary edition, with a separate teachers' guide have been printed and are being distributed by Prentice-Hall. The first hard-cover edition incorporating further revision is planned for 1967-68. Both the text materials and ESI-designed apparatus, which is supplied by Macalaster Scientific Corporation, are now available commercially on a limited basis. The major emphasis in the course is on the study of matter, through which a firm understanding of the atomic-molecular theory is established. Student laboratory work is of primary importance and is integrated directly in the body of the text; the results are not described. Since many junior high schools have little or no laboratory facilities, the equipment accompanying the written materials has been designed in such a way that the students can perform the experiments in ordinary classrooms. Achievement tests have been constructed and are now being pre-tested. The course is intended to be suitable for use both as a terminal course in physical science and as preparation for the study of biology, chemistry, and physics.

Further information can be obtained from the project director.

15. Conference and Report on Science in Secondary Schools, Grades 7–12. ROBERT STOLLBERG, Division of Science, Mathematics, and Engineering, San Francisco State College. (Grantee: National Science Teachers Association, 1201 16th Street, N.W., Washington, D.C. 20036.) (1959–1960)

R. Stollberg (ed.), *Planning for Excellence in High School Science* (National Science Teachers Association, Washington, D.C., 1961)

16. Conferences on Science Curriculum Planning. VERNE N. ROCKCASTLE, Science Education Division, Cornell University, Ithaca, N. Y. 14850. (1964)

With Professor Jean Piaget (University of Geneva, Switzerland) as leader, selected scientists, science educators, and psychologists met to share the latest research in cognitive learning in children, with emphasis on the implications of research on cognitive studies for curricular development in science at the elementary and junior high school levels. The conferences were held in the spring of 1964 at Cornell and at the University of California, Berkeley.

A final report on the conference is available from the project director.

17. Seminar on Children's Learning. JEROME S. BRUNER, Center for Cognitive Studies, Harvard University, Cambridge, Mass. 02138. (1963)

Following a planning conference, a two-week seminar in June 1963 brought together nearly 30 psychologists and a half dozen consultants from mathematics and the sciences to discuss the psychological processes involved in learning during the elementary school years. Working groups prepared papers on motivational problems in children's school learning, cognitive processes, and problems of stimulus presentation, with emphasis on such matters as sequence of presentation, reinforcement, rate, etc. An editorial committee chaired by Dr. Bruner has prepared a report to the supporting agencies (National Science Foundation and U.S. Office of Education): J. Bruner (ed.), *Learning About Learning*, U.S. Government Printing Office (1966).

Further information is available from the project director.

18. Regional Conferences of School Administrators on New Science Curricula. WILLIAM P. VIALL, Western Michigan University, Kalamazoo, Mich. 49001. (Former grantee: American Association for the Advancement of Science, 1515 Massachusetts Avenue, N.W., Washington, D.C. 20005.) (1962–1963) (1965)

The purpose of these conferences was to present to school administrators information relating to new curriculum developments in science. First-hand reports of experiences of supervisors and teachers with new materials and suggestions on introducing new programs into schools were presented. Meetings were held in Washington, Boston, New York, Chicago, Omaha, Portland (Oregon), San Francisco, Oklahoma City, and Miami Beach. An additional conference was held in April 1965 under a grant to Western Michigan University on the campus of that institution with essentially the same format as the 1962 conferences. In addition to the areas presented in the earlier conferences, there was emphasis on the teaching of science in the elementary schools and the teaching of mathematics.

The New School Science, a report of the 1962 conferences, is available from the project director or from the American Association for the Advancement of Science. A supplementary report on the 1965 conference is also available from the project director.

19. "Time for Science" Enrichment Series for Television. MRS. EDMUND D. CAMPBELL, The Greater Washington Educational Television Association, Inc., 1225 19th Street, N.W., Washington, D.C. 20036. (1959)

For rentals of color kinescopes write to: Ralph W. Collett, Norwood Studios, 926 New Jersey Avenue, N. W., Washington, D. C. 20001.

20. Television Course on Science for In-Service Elementary School Teachers. CHARLES T. LESTER, Graduate School, and W. B. BAKER, Department of Biology, Emory University, Atlanta, Ga. 30322. (1960–1964)

A program of 34 telecasts based on *Georgia Science Curriculum Guides* was prepared and has been used extensively in conjunction with workshops and discussion meetings with university scientists and high school science teachers to train in-service elementary school teachers in Georgia. Mimeographed material sent participants supplements the individual telecasts.

Further information may be obtained from the project directors.

B. Astronomy, Atmospheric and Earth Sciences

For additional projects related to this section see also:
- 13. Secondary School Science Project.
- 247. Ground Water Flow Models.

21. Astronomical Motion Pictures for Secondary Schools. C. D. SHANE, P. O. Box 582, Santa Cruz, Calif. 95061. (Grantee: The American Astronomical Society, 265 Fitz-Randolph Road, Princeton, N. J. 08540.) (1964–)

Two 30-minute astronomical motion pictures are being produced for showing in secondary schools. In each, a leading astronomer or astrophysicist will describe his research and relate it to the broader field of astronomy. The films are primarily intended to help raise the standards of the teaching of astronomy in secondary schools, and they will be widely distributed to schools and to educational television. The title of the first film is *A Radio View of the Universe* (Morton S. Roberts, National Radio Astronomy Observatory). The second film is entitled *Exploring the Milky Way* (George W. Preston, Lick Observatory). A third film is being considered on the origin of the elements (Geoffrey and E. Margaret Burbridge, University of California, La Jolla).

Further information may be obtained from Paul M. Routly, Executive Officer, The American Astronomical Society.

22. Motion Pictures, Filmstrips, and Slides in Meteorology. *(Secondary, College)* KENNETH C. SPENGLER, Executive Secretary, American Meteorological Society, 45 Beacon Street, Boston, Mass. 02108. (1960–)

A series of film materials on various phases of the atmospheric sciences is being prepared to supplement and strengthen the meteorology part of secondary school earth science curricula and to provide resource material for introductory college classes. Although consisting primarily of 16mm sound films in which a series of concepts can be brought together to interpret a given atmospheric phenomenon, certain resource materials are also being scheduled for production as 8mm or 16mm single-concept silent films and as slides and filmstrips.

Guidance for this program is provided by the Film Panel of the American Meteorological Society, which also maintains informal liaison with the principal scientist(s) and the advisory groups selected for each film. To date, three 16mm sound-color films, *Above the Horizon, Formation of Raindrops,* and *Solar Radiation I: Sun and Earth,* have been completed, as have single-concept silent films in 8mm and 16mm format on *Laboratory Nucleation of Supercooled Clouds, Homogeneous Nucleation and the Polar Nature of Ice Crystals,* and *Condensation Nuclei.* Work is in progress on additional topics, among which are: *Sea-Surface Meteorology, Planetary Circulation, Boundary Layer Meteorology, Hurricanes, Atmospheric Electricity, Convective Clouds,* and *Solar Radiation 2: Atmosphere and Spectrum.* Subject areas for future filming may include: local winds, air pollution, tornadoes, the ionosphere, hydrometeorology, air masses and fronts, weather map analysis and numerical weather prediction.

More detailed information can be obtained from the project director.

23. Monograph Series in Meteorology. Kenneth C. Spengler, Executive Secretary, American Meteorological Society, 45 Beacon Street, Boston, Mass. 02108. (1960–)

The first of approximately 20 paperbound monographs on various phases of the atmospheric sciences for science-oriented high school students will be published early in 1967 as a specially identified part of the Science Study Series of Doubleday and Co., Inc. The volumes will be concerned with various physical processes, principles and features of the atmosphere, and will be designed to inform, stimulate curiosity, and strengthen earth science curricula at the secondary school level. The American Meteorological Society, through a board of editors, collaborates with the editors (Educational Services Incorporated) of the Science Study Series in the selection and review of the manuscripts.

Monographs first published will include *Planetary Atmospheres, From Raindrops to Volcanos,* and *Local Weather Phenomena.* Others to be published within the series will cover such topics as hydrometeorology, cloud physics, upper atmosphere, atmospheric circulation, atmospheric optics and acoustics, atmospheric modeling, tornadoes, hurricanes, atmospheric and ocean tides, paleoclimatology, turbulence and diffusion, the jet stream, snow, and meteorological experiments.

More detailed information can be obtained from the project director.

24. Manual of Lecture Demonstrations, Laboratory Experiments, and Observational Equipment for Elementary Meteorology. *(Secondary, College)* Hans Neuberger, Department of Meteorology, The Pennsylvania State University, University Park, Pa. 16802 (1961–1962)

Fifty meteorological demonstrations, experiments, and observations are described. Illustrated directions for the construction of the necessary equipment are given. In addition to detailed construction drawings, photographs of completed apparatus are included Each section contains questions for students to answer, a list of needed materials, and the approximate cost of the apparatus (usually amounting to less than $1.00).

The manual is available at a cost of $2 per copy (make check payable to the Pennsylvania State University) by writing to the Department of Meteorology, The Pennsylvania State University, 322 Mineral Industries Building, University Park, Pa. 16802.

25. Earth Science Curriculum Project (ESCP). Chalmer J. Roy (Chairman, Steering Committee), Dean, College of Sciences and Humanities, Iowa State University of Science and Technology; Ramon E. Bisque (Director), The Earth Science Curriculum Project, P. O. Box 1559, Boulder, Colo. 80301. (Grantee: American Geological Institute, 1444 N Street, N.W., Washington, D.C. 20005.) (1963–)

At an eight-week writing conference conducted in the summer of 1964, 41 earth scientists, science educators, and secondary school teachers pooled their talent to produce preliminary materials for a modern junior high school earth science course, *Investigating the Earth.* This is an interdisciplinary, experience-centered course in which basic principles and concepts are applied to developing an understanding of the "how and why" of natural phenomena. Chemistry, mathematics and physics are utilized in showing how the earth science disciplines of astronomy, geology, geophysics, meteorology, oceanography and physical geography contributed to an understanding of man's environment.

Materials developed for use in the ESCP course include a text, laboratory manual, and teachers' guide. The text is organized into four major units: *Earth and Sun, Earth Cycles, The Earth's Past,* and *Earth and the Universe.* The investigations contained in the laboratory manual place emphasis on logical and systematic development of conclusions from careful observation and investigation. Each investigation in the manual is designed to reinforce basic ideas presented in the text.

Project materials were used by approximately 7600 students, mostly ninth graders, in 77 schools in 1964-65. Feedback on the effectiveness of the materials was obtained through written reports from the teachers, classroom observation by staff members, and objective testing of the students, and was used in revising the materials at a second writing conference in the summer of 1965. The revised materials will be tested in the schools a second year, revised again at a third writing conference, and then published by the Houghton Mifflin Company early in 1967.

In addition to the text, laboratory manual, and teachers' guide, supplementary material in the form of paperback pamphlets is being prepared and published. The first six pamphlets in the Reference Series have been published by Prentice-Hall, Inc. Three pamphlets in a Single Topic Series and three pamphlets in a Field Guide Series are in preparation. A number of short (8–12 minute) teaching films are also being planned to supplement classroom materials.

A quarterly *Newsletter* is published to keep interested persons informed of the progress and activities of the project.

R. L. Heller, "The Earth Science Curriculum Project—A Report of Progress," *Journal of Research in Science Teaching* 2 (4), 330-334 (1965).

C. J. Roy, "The Challenges of ESCP," Earth Science Curriculum Project *Newsletter* (7), 1-6 (1964).

26. Teaching Resources Development Program in the Geological Sciences (Duluth Conference).

ROBERT L. HELLER, Department of Geology, University of Minnesota. (Grantees: National Academy of Sciences-National Research Council, 2101 Constitution Avenue, N.W., Washington, D.C. 20418; University of Minnesota, Minneapolis, Minn. 55455.) (1959–1962)

The Duluth Conference held in the summer of 1959 was the first project undertaken by the American Geological Institute in its effort to improve earth science teaching in secondary schools. At the conference 35 geologists and other earth scientists, secondary school teachers, and science educators produced preliminary materials for a *Geology and Earth Science Sourcebook for Elementary and Secondary School.* Materials prepared at the conference were evaluated by scientists and teachers, revised and then published in 1962.

The primary objective of the American Geological Institute in producing the sourcebook was to bring together in one place up-to-date, well-organized subject matter that could be used by teachers with little or no training in the earth sciences. The sourcebook contains 18 chapters on the hydrosphere and lithosphere, one each on atmospheric science and astronomy, and three chapters designed to supplement high school biology, chemistry, and physics curriculum materials.

R. L. Heller (ed.), *Geology and Earth Science Sourcebook for Elementary and Secondary Schools,* Holt, Rinehart and Winston.

Further information may be obtained from the American Geological Institute, 1444 N Street, N.W., Washington, D.C. 20005.

27. Oceanography—Eight Narrated Filmstrips.

RICHARD C. VETTER, Committee on Oceanography, National Academy of Sciences-National Research Council, 2101 Constitution Avenue, N.W., Washington, D.C. 20418 (1962–1966)

A series of 35mm color filmstrips with 15-minute recorded narrations is being produced. Titles include: *A Career in Oceanography, Physical Oceanography, Geological Oceanography, Chemical Oceanography, Biological Oceanography, Marine Resources, Air-Sea Interaction,* and *Ocean Engineering.* Each filmstrip is designed to be used either as part of the complete series or independently in classes in biology, physics, chemistry, and the earth sciences. The series will be manufactured by Encyclopaedia Britannica Films and be made available both in entire sets and as separate parts through the distribution systems of E. B. Films and other qualified distributors in late 1966. A narration booklet and bibliography will accompany each set, and a supplemental book containing articles written by leading marine scientists in each of the above fields will be available.

28. Columbia-Lamont Marine Science Films.

(Secondary, College) MAURICE EWING, Lamont Geological Observatory, Columbia University, Palisades, N. Y. 10964. (1963–)

The series of four 16mm films (sound-color, 25–30 min. each) is designed to bring important recent advances in the study of the maritime portions of the earth into high school and college classrooms and thus into the mainstream of science education. Study guides will accompany the films.

Each of the films is focused on a principal investigator who narrates portions of the film. His working methods and problems are shown and described and the principal facts about that particular discipline are communicated.

History Layer by Layer (David B. Ericson, Lamont Geological Observatory), shows the process of raising deep sea cores from the floor of the ocean and how laboratory examination of fossil remains in the core reveals climates of the past. For use in earth science, general science or biology courses, with units on earth history, climates of the past, and the Pleistocene era.

Adaptation to a Marine Environment (Malcolm Gordon, University of California, Los Angeles), filmed on location in Thailand, describes attempts to find out how an unusual frog native to the mud flats can live alternately in fresh and salt water. The film is intended for use in biology, health, physical science, or general science courses, with units on osmosis, hydrostatic pressure, diffusion, blood plasma, absorption of food, excretion of waste.

Waves Across the Pacific (Walter Munk, Institute of Planetary Sciences, La Jolla, Calif.), shows a study of deep ocean waves from their origin in storms off Antarctica to the breaking waves on an Alaskan beach. Energy spectra, wave amplitude, and wave length are recorded at island stations along the path of the wave train. The film may be used in physical science, general science, or mathematics courses with units on wave propagation.

The Earth Beneath the Sea (Maurice Ewing, Lamont Geological Obstervatory), explains how geophysicists study the portion of the earth beneath the ocean waters. Samples are obtained by means of instruments attached to miles-long cables. Where samples cannot be obtained, recording instruments give clues to the nature of the material and the processes going on within it. The film is meant for use in earth science, general science, and physical science courses, with units on earth history, geophysics, and oceanography.

The films are produced under the supervision of the Lamont senior staff, with the aid of an advisory committee representing other institutions. Commercial distribution is being arranged.

For further information write to the project director.

C. Biology

For additional projects related to this section see also:

18. Regional Conferences of School Administrators on New Science Curricula.
79. Overhead Projection Series of Lecture Experiments in the Sciences.
93. Committee on Educational Policies in Biology.
99. Guidebook for Introductory College Courses in Mycology.
102. Film Series: "The Promise of the Life Sciences."
103. Plant Science Films.
105. Short Films in Microbiology.
107. Cinephotographic Techniques in Morphology.
112. Inexpensive Electronic Equipment for Quantitative Physiological Studies.
114. Sectionable Model of Human Brainstem for Individual Student Use.
115. Working Model of Human Circulatory System.
121. Students' Warburg and Other Respirometric Apparatus.

29. Biological Sciences Curriculum Study (BSCS). ARNOLD B. GROBMAN (Chairman), College of Arts and Sciences, Rutgers, The State University; WILLIAM V. MAYER (Director), Wayne State University. (Grantees: American Institute of Biological Sciences, 2000 P Street, N.W., Washington, D.C. 20036 (1959–1962); University of Colorado, Boulder Colo. 80301.) (1962–)

The BSCS is a total program of curriculum improvement for secondary-school biology including texts and laboratory materials for students of diverse abilities from below-average to gifted in grades 10–12 as well as for teachers and administrators. Stress is placed upon teaching major principles of biology in depth, with special emphasis on investigative laboratory work and the teaching of science as inquiry. BSCS policy is regulated by a 27-member Steering Committee and a six-member Executive Committee. Content for each major program is reviewed by a special committee of persons well qualified in a particular field.

Three versions of a modern high school course in biology are now available for use in the tenth grade. Although approximately 70 percent of the content is common to all three versions, each one approaches the study of biology from a distinctive point of view. The Blue Version uses a molecular-biochemical-evolutionary approach; the Green Version, an ecological-evolutionary approach; the Yellow Version, a cellular-biochemical-evolutionary approach. The three courses are equivalent in depth of content and designed for students of average and above-average ability. Each version includes a text, laboratory manual, teachers' guide, quarterly tests, and a comprehensive final examination.

BSCS laboratory blocks provide six-week programs of concentrated investigation suitable for regular classes, and cover a wide range of areas, including development, ecology, behavior, genetics, and metabolism. A book describing many items of home-made, relatively inexpensive equipment and simplified laboratory techniques has also been published.

A special handbook for teachers discusses the aims, philosophy, and methods of the BSCS and also presents a set of "Invitations to Inquiry," prepared discussions on selected biological problems designed to bring out aspects of scientific methods and philosophy.

For less able students the BSCS has prepared a set of special materials planned to aid those who have difficulty with the regular BSCS versions. A commercial edition of these materials will become available by August 1966.

For very capable students the BSCS has published a series of four volumes containing a total of 160 selected investigations they might wish to undertake. In addition, a second course in biology has been devised for schools that wish to offer a second year of the subject, usually in the twelfth grade.

Other aids for students, teachers, and schools include pamphlets on special topics in biology, bulletins and special studies on biological education and the education of teachers, films on laboratory techniques, and single-topic films intended to supplement all the diverse course materials.

The BSCS is also conducting an extensive evaluation program and is cooperating with groups of biologists and teachers in many countries in adapting BSCS materials and approaches for use in their schools.

The materials available include the texts: Blue Version—*Biological Science: Molecules to Man* (Houghton Miffln Co.), Green Version—*High School Biology, BSCS Green Versian* (Rand McNally & Co.), Yellow Version—*Biological Science: An Inquiry Into Life* (Harcourt Brace & World Co.); BSCS Version Quarterly Test (version publishers); BSCS Comprehensive Final Exam (The Psychological Corp., for classroom use only); and BSCS Laboratory Blocks (D. C. Heath and Co.): *Plant Growth and Development, Animal Growth and Development, Microbes: Their Growth, Nutrition and Interaction, The Complementarity of Structure and Function, Regulation in Plants by Hormones, Field Ecology, Animal Behavior, The Molecular Basis of Metabolism, Physiological Adaptation, Genetic Continuity, Life in the Soil.*

Innovations in Equipment and Techniques for the Biology Teaching Laboratory (D. C. Heath and Co.); *Biology Teacher's Handbook* (John Wiley & Sons, Inc.); *Research Problems in Biology: Investigations for Students,* Series One, Two, Three, and Four (Doubleday & Co.); *BSCS Biology, Special Materials* (Holt, Rinehart and Winston); *BSCS Biology, Second Course: The Interaction of Experiments and Ideas* (Prentice-Hall, Inc.); *BSCS Bulletin Series* (University of Colorado); *BSCS Special Publication Series* (University of Colorado).

BSCS Pamphlet Series (D. C. Heath and Co.): *Guideposts of Animal Navigation* (Carr), *Biological Clocks* (Brown), *Courtship in Animals* (Meyerriecks), *Bioelectricity* (Suckling), *Biomechanics of the Body* (Du Brul), *Present Problems About the Past* (Auffenberg), *Metabolites of the Sea* (Nigrelli), *Blood Cell Physiology* (Gordon), *Homeostatic Regulation* (Overmire), *Biology of Coral Atolls* (Boolootian), *Early Evolution of Life* (Young, Ponnamperuma), *Population Genetics* (Wallace), *Slime Molds and Research* (Alexopoulos, Koevening), *Cell Division* (Mazia), *Photoperiodism in Animals* (Farner), *Growth and Age* (Milne and Milne), *Biology of Termites* (Miller), *Biogeography* (Neill), *Hibernation* (Mayer), *Animal Language* (Collias), *Ecology of the African Elephant* (Quick), *Cellulose in Animal Nutrition* (Hungate), *Plant Systematics* (Raven, Mertens), *Photosynthesis* (Gaffron).

BSCS Techniques Films for teachers, each 16mm, sound-color (Ealing Corp., Thorne Films): *Bacteriological Techniques* (5 min.), *Culturing Slime Mold Plasmodium* (5 min.), *Genetics Techniques : Handling Drosophila* (3 min.), *Measuring Techniques* (14 min.), *Neurospora Techniques* (8 min.), *Paper Chromatography* (14 min.), *Removing Frog Pituitary* (1 min.), *Smear and Squash Techniques* (5½ min.), *Weighing Techniques* (8 min.).

BSCS Single Concept Films are being developed that stress the learning of important biological principles through a process of inquiry.

The Story of BSCS (BSCS information film, University of Colorado).

The BSCS *Newsletter* is available from the Biological Sciences Curriculum Study, University of Colorado.

B. Glass, "Renascent Biology: A Report on the AIBS Biological Sciences Curriculum Study," *The School Review* 70, 16 (1962).

W. C. Van Deventer, "BSCS Biology," *School Science and Mathematics* (February 1965).

30. Television Course on "The New Biology." *(Secondary, College)* JOHN W. TAYLOR, Learning Resources Institute, 10 Columbus Circle, New York,

N. Y. 10019; RAY KOPPLEMAN, Department of Biochemistry, The University of Chicago. (Grantee: Learning Resources Institute; cosponsor: American Institute of Biological Sciences.) (1961–1962)

This television course of 160 half-hour lecture demonstrations was designed to help improve the teaching of biology in the Nation's secondary schools and colleges by acquainting science and biology teachers with new developments in biology. In 1963–64, "Highlights of the New Biology," a core of 90 lessons from the course, including 12 lessons which have been remade to include new and revised content, was telecast three times a week on 42 educational stations.

Further information on the availability of video tapes and kinescopes for educational use: National Educational Television Film Service, Indiana University, Bloomington, Ind. 47405.

31. Films on the Nature of Viruses. *(Secondary, College)* WENDELL M. STANLEY, Virus Laboratory, University of California, Berkeley, Calif. 94720. (1959–1960)

Eight 16mm, black-and-white, sound films, each 30 minutes, were designed to help acquaint high school and college students and teachers and the general public with recent accomplishments of research in virology and implications for understanding certain fundamental problems in biology, and to broaden general appreciation of the role of research in basic science. They were prepared by the project director and six senior staff members of the Laboratory, aided by E. G. Valens, Jr., and in cooperation with educational television station KQED-TV, San Francisco, W. A. Palmer Films, Inc., and the University's Department of Visual Communications. They have been shown on educational television stations throughout the country. Titles of the films are: *Between the Living and the Non-living, Giant Molecules, The Stuff of Life, Viral Genes, How Viruses Kill, Threads of Life, Killers and Carcinogens,* and *Cancer.*

W. M. Stanley and E. G. Valens, Jr., *Viruses and the Nature of Life* (E. P. Dutton and Company, New York, 1961). Based on the television series.

Film rental and purchase, television use: National Educational Television Film Service, Indiana University, Bloomington, Ind. 47405.

32. Three Educational Films on Myxomycetes. *(Secondary, College)* T. R. PORTER, College of Education, State University of Iowa, Iowa City, Iowa 52240. (1960–1961)

Films are as follows:

Slime Molds I: Life Cycle (16mm, sound-color or black-and-white, 30 min.) The complex life cycle and uniqueness of myxomycetes is revealed in detail by a combination of microscopic and cinephotomicrographic techniques and animation.

Slime Molds II: Collection, Culitvation and Use (16mm, sound-color, 19 min.) Animation reviews a few selected studies on slime molds; student projects are suggested; and several classroom demonstrations are shown.

Slime Molds III: Identification (16mm, sound-color, 24 min.) The use of a key is illustrated by comparing a modified portion of Professor G. W. Martin's key to a road map, each "road" being followed until the main families of myxomycetes are identified. Animation is used to show the parts of fruiting bodies used in identification.

Rental or sale of films: Audio-Visual Center, State University of Iowa.

For further information, address the project director.

33. "Living Biology" Film Series. *(Secondary, College)* ROMAN VISHNIAC, Yeshiva University, 110 West 57th Street, New York, N. Y. 10033. (1960–)

A series of 16mm sound-color films is being produced to show observations and studies of the behavior of animals and the life of plants in their natural habitats. The "Living Biology" films are designed to show the actual life and functions of organisms—their processes, behavior, structure, and physiology. The camera becomes, in effect, a part of the biosphere. Students see the events happening in native environments as if they were the original investigators; they see the dynamic living processes upon which current interpretation and theory are based. Tentative film titles include: *The Living Tide, The Life of the Pond, Protozoa, Microscopic Plants—Protophyta, From Sponges to Mollusca, Arthropoda Through Vertebrata, Physiology of Life, Life of the Sea Floor, Plankton of the Sea, Biology of the Bee, Growth and Development, Microbiology.* Distribution of films will begin during 1966.

34. Graphic Methods for Teaching Physiology. *(Secondary, College)* FRED E. D'AMOUR, Department of Zoology, University of Denver, Denver, Colo. 80210. (1961–1962)

Devices have been built from inexpensive and readily available components to provide graphic demonstrations of the following physiological functions: respiratory system, circulatory system, muscle action, knee jerk, distribution of optic nerves, functioning of the muscles of the eyeball, nature of the nerve impulse, and properties of conduction at the synapse.

A small-animal respirator, using a small synchron motor as timer, plus a solenoid magnet and a pair of plastic bellows, has been designed to be built for $10.

Further information can be obtained from the project director.

35. Plant Growth Chamber. *(Secondary, College)* F. W. Went, Director, Missouri Botanical Garden, 2315 Tower Grove Avenue, St. Louis, Mo. 63110. (Present address: Desert Research Institute, University of Nevada, Reno, Nev. 89507.) (1960–1963)

Small, climate-controlled plant growth chambers have been constructed which can be utilized by schools and colleges which lack a suitable greenhouse. The chambers permit control of temperature, light, ventilation, and moisture. For detailed information on construction, along with instructions for classroom experiments which use the chambers to study such problems as rooting of cuttings, germination of plants, growth and development, and flowering responses to photoperiod, see Wray Darr, "Classroom Greenhouse for Biology Teaching," *The Science Teacher* 30, 8 (1963).

35A. A special Issue on Plant Pathology for the American Biology Teacher. *(Secondary, College)* C. W. Boothroyd, Department of Plant Pathology, Cornell University, Ithaca, N. Y. 14850. (Grantee: American Phytopathological Society.) (1966)

In producing a special issue of the *American Biology Teacher* devoted entirely to the one topic, this project seeks to (1) acquaint biology teachers with the science of plant pathology as a means of expressing many of the concepts of general biology; and (2) offer these teachers some simple, but challenging exercises that can be performed in the classroom, the laboratory, and the field.

D. Chemistry

For additional projects related to this section see also:

79. Overhead Projection Series of Lecture Experiments in the Sciences.
128. Films for College Chemistry.
129. Equipment and Experiments for Teaching Instrumental Analysis.
130. Supplementary Teaching Aids for Introductory Chemistry.
133. Apparatus for Chemical Analysis and Preparation on the Micro and Semi-Micro Scale.
139. New Atomic, Molecular, and Crystal Models.

36. Chemical Education Material Study (CHEM Study). Glenn T. Seaborg (Chairman), Atomic Energy Commission, Washington, D.C. 20545; George C. Pimentel (Director), Department of Chemistry, University of California, Berkeley, Calif. 94720. (1959–)

CHEM Study has been experimenting with means for making a first chemistry course as profitable as possible for all students who wish to take such a course. The text, laboratory manual, teachers' guide, and motion pictures heavily emphasize an experimental approach to chemistry and the importance of laboratory work. This experimental emphasis is used to develop such major concepts as dynamic equilibrium, rates and mechanisms of reactions, chemical bonding, structural ideas, and the systematics of chemistry in terms of the periodic table. The course seeks to present chemistry from the point of view of a person intimately involved in the profession of chemistry, but in terms both interesting and comprehensible to beginning students. Published materials were in use by about 350,000 students during the 1965–66 school year. Evaluative surveys that have been and are being undertaken are reported in the *Newsletter*. The text is being translated into Chinese, French, Gujerati, Japanese, Korean, Portuguese, Spanish, Thai and Turkish.

The following printed materials are available from the cooperating publisher, W. H. Freeman and Company: *Chemistry—An Experimental Science* (textbook, laboratory manual, teachers' guide), two alternate sets of seven CHEM Study Achievement Examinations, and two programed instruction pamphlets on *Exponential Notation* and *The Slide Rule*. Wall charts developed by the Study are available from the Central Scientific Company, and from the W. M. Welch Scientific Company. Two monographs have been written as extensions of the course materials. These are G. T. Seaborg's *Man-Made Transuranium Elements* and J. A. Campbell's *Why Do Chemical Reactions Occur?*, both published by Prentice-Hall.

Titles of films (each 16mm, sound-color except as noted), produced by the Study and distributed by Modern Learning Aids, are:

Gases and How They Combine, 22 min., George C. Pimentel; *Gas Pressure and Molecular Collisions,* black-and-white, 21 min., J. Arthur Campbell; *Electric Interactions in Chemistry,* 21 min., J. Leland Hollenberg and J. Arthur Campbell; *Chemical Families,* 22 min., J. Leland Hollenberg and J. Arthur Campbell; *Molecular Motions,* 13 min., J. Arthur Campbell; *Vibration of Molecules,* 12 min., Linus Pauling and Richard M. Badger (in cooperation with American Chemical Society); *Introduction to Reaction Kinetics,* 13 min., Henry Eyring (in cooperation with American Chemical Society); *Equilibrium,* 24 min., George C. Pimental; *Catalysis,* 17 min., Richard E. Powell (in cooperation with Manufacturing Chemists' Association); *Acid-Base Indicators,* 19 min., J. Arthur Campbell; *Nitric Acid,* 18 min., Harry H. Sisler (in cooperation with Manufacturing Chemists' Association); *Crystals and Their Structures,* black-and-white, 22 min., J. Arthur Campbell; *Molecular Spectroscopy,* 23 min., Bryce Crawford, Jr. and John Overend; *The Hydrogen Atom—As Viwed by Quantum Mechanics (standard version),* 13 min., George C. Pimentel; *The Hydogen Atom—As Viewed by Quantum Mechanics (advanced version),* 20 min., George C. Pimentel; *Ionization Energy,* 22 min., Bruce H. Mahan; *Shapes & Polarities of Molecules,* 18 min., David Dows; *A Research Problem: Inert (?) Gas Compounds,* 19 min., George C. Pimentel and J. J. Turner; *Synthesis of an Organic Compound,* 22 min., T. A. Geissman; *Mechanism of an Organic Reaction,* 20 min., Henry Rapoport; *Bromine—Element from the Sea,* 22 min., J. Leland Hollenberg and James E. Magner; *Vanadium—A Transition Element,* 22 min., Robert Brasted; *High Temperature Research,* 19 min., Paul W. Gilles; *Transuranium Elements,* 23 min., Glenn T. Seaborg; *Electrochemical Cells,* 22 min., J. Arthur Campbell and June S. Ewing; *Chemical Bonding,* 16 min., George C. Pimentel; and *Biochemistry and Molecular Structure,* 22 min., Donald E. Rounds.

Two lecture films for teacher preparation, *Pimentel Discusses the Hydrogen Atom* and *Pimentel Discusses Chemical Bonding,* have recently been produced. A number of filmstrips and 8mm film loops have also been prepared. An information film is in preparation.

Orders for books, films, etc., should be sent directly to the distributor concerned. A brochure describing the film and a teachers' guide for the films may be obtained by writing to Modern Learning Aids.

Requests for general information and for subscription to the CHEM Study *Newsletter* should be addressed to David W. Ridgway, Executive Director, CHEM Study, Lawrence Hall of Science, University of California, Berkeley, Calif. 94720.

H. Bassow, "The CHEM Study Course, an Objective Appraisal," *Science and Mathematics Weekly* 3, 205 (1963).

R. J. Merrill, "Chemistry—an Experimental Science," *The Science Teacher* 30 (3), 26 (1963).

L. E. Strong and G. C. Pimentel, "Greetings from CBA and CHEMS," *Chemistry* 37 (1), 24 (1964).

37. Chemical Bond Approach Project (CBA).

LAURENCE E. STRONG, Department of Chemistry, Earlham College, Richmond, Ind. 47375. (1958–)

This high school course is presented through a textbook and laboratory guide designed to be used together. These materials were devolped and tested over several years (1959-63) in high school classrooms throughout the country. The development in the text proceeds in five parts: The Nature of Chemical Change; Electrical Nature of Chemical Systems; Models as Aids to the Interpretation of Systems; Bonds in Chemical Systems; Order, Disorder, and Change. A systematic attempt is made to distinguish between the data produced by experiment and imaginative ideas used to interpret data. The course emphasizes logical schemes which permit students to investigate and interpret a variety of chemical systems; for instance, the use of a simplified molecular orbital treatment of molecular structure is designed to help students understand the fundamental basis of current thinking about the electrical nature of matter. The closely related laboratory work develops from early experiments with rather complete directions to experiments late in the course which leave much of the design to students. New types of experiments include the use of the method of continuous variations and simple thermochemical measurements. A major feature of the laboratory work is a scheme of vertical development whereby groups of experiments are designed to fit together in such a way that students develop both technical facility and interpretive skill in moving from simple to fairly complex investigations.

A set of achievement examinations to accompany the course is available from the McGraw-Hill Book Company. Translations in Spanish, Portuguese, and Japanese of the text materials are in preparation. A number of programed instruction materials including programs on electrostatics, charge cloud models, and thermochemistry are being developed to accompany parts of the course.

Textbook: *Chemical Systems* (McGraw-Hill Book Co., Inc.). Teachers' guide available.

Student laboratory guide: *Investigating Chemical Systems* (McGraw-Hill Book Co.). Teachers' guide available.

Collection of reprints: *Supplemental Readings for Chemical Bond Approach,* reprinted from *Journal of Chemical Education* (Chemical Education Publishing Co.). The collection of reprints and a chart of atomic and ionic radii are available from the project office.

L. E. Strong and M. K. Wilson, "Chemical Bonds: A Central Theme for High School Chemistry," *Journal of Chemical Education,* 35, 56 (1958).

L. E. Strong, "Facts, Students, Ideas," *Ibid.* 39, 126 (1962).

L. E. Strong, "Chemistry as a Science in the High School," *The School Review* 70, 44 (1962).

R. W. Heath and D. W. Stickell, "CHEM and CBA Effects on Achievement in Chemistry," *The Science Teacher* 30, 5 (1963).

38. Laboratory Experiments for Chemistry Courses. *(Secondary, College)* H. A. Neidig, Department of Chemistry, Lebanon Valley College, Annville, Pa. 17003. (1964–1966)

The first phase of this projet consisted of an 8-week summer institute in which thirty-one secondary school chemistry teachers participated during the summer of 1965. The institute program was supervised by a group of secondary-school teachers and college professors. During the first part of the institute, the participants conducted six different laboratory investigations using recent developments in laboratory operations. Sufficient data were collected to permit statistical treatment. A number of chemical systems were investigated using several different experimental approaches for the latter part of the institute. Data were obtained that were related to specific concepts or chemical principles. Representative of the type of investigations that were conducted was a study of aqueous solutions of sodium phosphate, of sodium hydrogen phosphate, of sodium dihydrogen phosphate, and of phosphoric acid using potentiometric titrations and thermochemical procedures. The resulting data appear to be useful for relating enthalpy, free energy, and entropy changes and for comparing the nature of the various phosphate species.

The second phase of the project was conducted in cooperation with a number of high schools, colleges and universities during the 1965–66 academic year The experiments written on the basis of the information obtained during the institute were evaluated. Feedback information was obtained from visits to high schools, discussions in an in-service institute, and correspondence. On the basis of this information, those experiments that appear to be the most effective will be rewritten or modified. The third phase of the project will involve submitting specific experiments for publication in appropriate journals. It is hoped that investigations described in the articles submitted for publication will serve as source material for individuals who are interested in developing their own experiments.

39. Visual Aids for Teaching Chemistry. *(Secondary, College).* R. T. Sanderson, Department of Chemistry, Arizona State University, Tempe, Ariz. 85281. (1959–1964)

Three 45-minute sound-color, filmed lectures demonstrate the construction and use of new chemistry teaching aids developed previously: (1) *Atomic Models, Valence, and the Periodic Table;* (2) *New Models of Molecules, Ions, and Crystals: Their Construction and General Use in Teaching Chemistry;* and (3) *A Special Set of Models for Introducing Chemistry.* Other work includes (1) further development of the models described in the films, (2) preparation of a laboratory exercise on valence and a lecture aid for teaching atomic structure, and (3) construction of a portable three-dimensional periodic table.

R. T. Sanderson, *Teaching Chemistry with Models* (D. Van Nostrand Co., Inc., 1962). This book describes in detail the teaching uses of the new atomic and molecular models and tells how to build hundreds of models.

The following papers in the *Journal of Chemical Education* are of either direct or supplementary interest:

"Models for Demonstrating Electronegativity and Partial Charge" 36, 507 (1959); "Atomic Models in Teaching Chemistry" 37, 307 (1960); "Valence: A Laboratory Exercise for General Chemistry" 37, 261 (1960); "An Aid to Teaching Electronic Configurations of Atoms" 37, 262 (1960); "Principles of Chemical Bonding" 38, 382 (1961); "Principles of Chemical Reaction" 41, 13 (1964); "Principles of Hydrogen Chemistry" 41, 331 (1964); "Principles of Halogen Chemistry" 41, 361 (1964); "Principles of Oxide Chemistry" 41, 415 (1964); "A Rational Periodic Table" 41, 187 (1964).

Film can be rented or purchased from the Extension Division, University of Iowa, Iowa City. Suppliers of styrofoam are listed in the book on models. Models patterned after those described in this book are available from Macro Models.

E. Mathematics

For additional projects related to this section see also:

2. Minnesota School Mathematics and Science Teaching Project (MINNEMAST).

251. Committee on the Undergraduate Program in Mathematics (CUPM).

255. Power Series and the Elementary Functions.

257. Course in Applications of Mathematics for Secondary School Teachers.

267. Course in Mathematics for Prospective Junior High School Teachers.

268. Mathematics Courses for Prospective Elementary School Teachers.

269. Geometry Course for Prospective High School Mathematics Teachers.

270. Course in the Number System for Elementary School Teachers.

271. Films and Other Teaching Materials for College Mathematics.

40. School Mathematics Study Group (SMSG). Clarence E. Hardgrove (Chairman), Northern Illinois University, De Kalb, Ill. 60115; E. G. Begle (Director), Cedar Hall, Stanford University, Stanford, Calif. 94305. (Grantees: Yale University and Stanford University.) (1958–)

The primary purpose of the SMSG is to foster research and development in the teaching of school mathematics. So far, major objectives of the Study Group have been the preparation of sample text materials designed to illustrate the kind of curriculum which the members of the group feel is demanded by the increased use of science, technology, and mathematics in our society, and the preparation of materials designed to help teachers prepare themselves to teach such a curriculum. Currently, consideration is being given to the planning of an integrated, sequential mathematics curriculum for grades 7-12 which will take full advantage of the last ten years of mathematics curriculum development. Arrangements of topics will be chosen to maximize the efficiency of the program and thus permit inclusion of the equivalent of a full year of calculus and some of the basic notions of probability and numerical analysis. The relationships between mathematics and the sciences will play an integral part from the beginning. A second major activity of the SMSG is the contribution of the National Longitudinal Study of Mathematical Abilities in which students originally in grades 4, 7, and 10 are being followed to determine the effects of conventional, SMSG, and other new course sequences on performance in mathematics and science in school and college. In addition, SMSG carries out experimentation with various specialized materials designed to fulfill specific needs in mathematics education. Available materials include:

1. Elementary School Texts—

The elementary-school materials are designed for use in self-contained classrooms and are suitable for average students as well as for those of higher ability. For each of the grades 1 through 6, there are a student text and a teachers' commentary; for kindergarten, there is only a teachers' book. *Mathematics for the Elementary School,* K-3 (Yale University Press, A. C. Vroman, Inc.); *Mathematics for the Elementary School,* Grades 4, 5, 6 (Yale University Press).

2. Junior High School Texts—

These texts review and extend the mathematics of the elementary school in such a way as to provide a sound intuitive foundation for high school courses. A considerable amount of informal geometry is included. Each text is accompanied by an extensive teachers' commentary. *Mathematics for Junior High School,* Vol. I (grade 7), and Vol. II (grade 8), (Yale University Press).

3. Texts for Slower Students (Yale University Press)—

These texts include the bulk of the mathematics for grades 7-9 listed in the series above and below, but with the level of reading difficulty reduced. It is expected that students will proceed through these materials at a slower rate. Each text is accompanied by an extensive teachers' commentary. *Introduction to Secondary School Mathematics,* Vol. I (grade 7), Vol. 11 (grade 8), and *Introduction to Algebra* (grade 9).

4. High School Texts—

These texts are designed for average and above-average students in a college preparatory program. *Geometry with Coordinates* is designed as an alternative to *Geometry* with more emphasis on analytic geometry. *Matrix Algebra* and *Analytic Geometry* are intended for students who have completed the prerequisites for calculus but wish to postpone study of this subject until college. Each text is accompanied by an extensive teachers' commentary. *First Course in Algebra* (Yale University Press); *Geometry* (Yale University Press); *Geometry with Coordinates* (Yale University Press); *Intermediate Mathematics* (Yale

University Press); *Elementary Functions* (Yale University Press); *Introduction to Matrix Algebra* (Yale University Press); *Analytic Geometry* (A. C. Vroman, Inc., Yale University Press); *Calculus* (A. C. Vroman, Inc.).

5. Supplementary Materials (A. C. Vroman, Inc.)—
A variety of booklets is available. Their common characteristic is that each requires less than a full academic year. In addition to the revised version of *Mathematics through Science*, the unit *Mathematics and Living Things* is available in preliminary form. It is designed for use at the eighth-grade level and uses biological experiments to motivate mathematical ideas. *Mathematics Through Science*, Parts I, II, and III for use respectively in any seventh- and eighth-grade course and with ninth-grade general mathematics courses. *Junior High School Mathematics Units, Number Systems; Junior High School Mathematics Units, Geometry; Junior High School Mathematics Units, Applications; Junior High School Supplementary Unit; Essays on Number Theory I; Essays on Number Theory II; Development of the Real Number System; Selected Units, Grade 4; Mathematics and Living Things.*

6. Supplementary and Enrichment Series (A. C. Vroman, Inc.)—
Most of these pamphlets are designed to allow teachers to try short modern treatments of particular mathematics topics in class. Student text and teachers' commentaries are available for most of the topics, though some pamphlets are designed for independent study or enrichment. *Functions, Circular Functions, The Complex Number System, The System of Vectors, Non-Metric Geometry, Plane Coordinate Geometry, Inequalities, Numeration, Algebraic Structures, Factors and Primes, Mathematical Systems, Systems of First Degree Equations in Three Variables, Radioactive Decay.*

7. New Mathematical Library (L. W. Singer Co., reduced price edition; Random House, trade edition)—
This consists of a series of short expository monographs on various mathematical subjects. The objectives of this series are the dissemination of good mathematics in the form of elementary topics not usually covered in the school curriculum, the awakening of interest among gifted students, and the presentation of mathematics as a meaningful human activity. *Numbers Rational and Irrational* (Niven), *What is Calculus About?* (Sawyer), *An Introduction to Inequalities* (Beckenbach, Bellman), *Geometric Inequalities* (Kazarinoff), *The Contest Problem Book* (Salkind), *The Lore of Large Numbers* (Davis), *Uses of Infinity* (Zippin), *Geometric Transformations* (Yaglom, Shields), *Continued Fractions* (Olds), *Graphs and Their Use* (Ore), *Hungarian Problem Book I* (Rapaport), *Hungarian Problem Book II* (Rapaport), *Episodes from Early Mathematics* (Aaboe), *Groups and Their Graphs* (Grossman, Magnus), *Mathematics of Choice* (Niven), *From Pythagoras to Einstein* (Friedrichs), *The MAA Problem Book II* (Salkind).

8. Studies in Mathematics (A. C. Vroman, Inc.)—
All the books in this series are intended for teachers. Some provide the background for a specific student course, and others are more general in nature. *Euclidean Geometry Based on Ruler and Protractor Axioms, Structure of Elementary Algebra, Geometry, Concepts of Informal Geometry, Number Systems, Intuitive Geometry, Concepts of Algebra, Brief Course in Mathematics for Elementary School Teachers, Applied Mathematics in the High School, Mathematical Methods in Science, A Brief Course in Mathematics for Junior High School Teachers, In-service Course for Primary School Teachers, Introduction to Number Systems.*

9. Study Guides in Mathematics (A. C. Vroman, Inc.)—
These consist of annotated bibliographies on various parts of mathematics, all bound in one pamphlet. They are intended for independent teacher study and for course planning for teachers. The newest in this series is a study guide on Digital Computing and Related Mathematics and consists essentially of an annotated bibliography intended for teachers interested in the topic of high-speed computation as it might appear in the high school program. Other study guides available are on Algebra, Calculus, Geometry, Number Theory, and Probability and Statistics.

10. Filmed Course for Elementary School Teachers (Modern Learning Aids)—
This course consists of 30 half-hour color films. The series is intended primarily for in-service elementary school teachers and is intended to furnish a foundation in mathematics for any of the newer elementary school mathematics programs. *Brief Course in Mathematics for Elementary School Teachers* from the series Studies in Mathematics is designed to accompany the filmed course. The first 16 of these films provide a suitable background in mathematics for teachers of grades K–3. The remainder, building on these, is

concerned with mathematics normally taught in grades 4–6.

In addition to the above, the Study Group has (1) arranged for translation of some publications into Spanish, (2) prepared programed learning materials in some areas, and (3) prepared numerous reports and supplementary publications. For information about the activities of the SMSG or to receive the SMSG *Newsletter*, write the project director.

41. University of Illinois Committee on School Mathematics (UICSM). MAX BEBERMAN, University of Illinois Committee on School Mathematics, 1210 West Springfield, Urbana, Ill. 61801. (1962–)

In December 1951 the Colleges of Education, Engineering, and Liberal Arts and Sciences established the University of Illinois Committee on School Mathematics (UICSM) to investigate the content and teaching of college-preparatory mathematics in grades 9–12. Financial support from the Carnegie Corporation of New York made possible the development of a variety of instructional materials and their experimental trial in schools throughout the country. Texts and teachers' guides for grades 9–12 were developed. To enable teachers to help in the experimental trial of materials and teaching approaches, the project staff conducts summer training institutes and has also produced teacher-training films for use in them. With NSF support, new footage has been added, resulting in a 50–film series for training of ninth-grade algebra teachers. (See item 52.)

In 1962, With National Science Foundation support, the UICSM began the development of new instructional materials for junior and senior high schools. Materials currently under devolpment include texts, teachers' guides, and visual aids intended for use with underachieving students in grades 7 and 8, and texts and teachers' guides for a new two-year geometry sequence for the senior high school. Among the topics included in the grades 7–8 materials are a detailed study of the arithmetic of rational numbers expressed as common fractions, decimal fractions, or percents, an intuitive study of geometry approached through consideration of translations, rotations and reflections in the plane, and an intuitive introduction to elementary algebra. The course is intended for students with records of underachievement in mathematics, especially those whose underachievement may reasonably be ascribed to cultural handicaps. Preliminary versions of the course were tried with students in public schools in Champaign-Urbana, Illinois, 1964–65. A revised version of the seventh grade portion will be tried in several large metropolitan centers during 1966–67. The texts have been designed with special attention to the appearance of the pages (five-color printing, cartoon strips, large pictorial displays), and an attempt has been made to minimize the requisite reading skills. The new UICSM materials being developed for senior high school constitute a two-year vector geometry course for grades 10 and 11, or 11 and 12. That course introduces translations (vectors) as mappings of Euclidean three-space on itself, many of the "traditional" geometrical theorems, introduction to the study of groups, vector spaces, the concepts of linear dependence and linear independence, the nature of distance functions, and trigonometry. In an attempt to illustrate the nature of deductive systems, postulates for an inner product space of translations are introduced gradually, each one chosen to assign to the space those properties which intuition requires for it to be useful as a model of the three-dimensional world of experience. Preliminary versions of the vector geometry course have been tried in the University of Illinois laboratory high school during 1963–64 and 1964–65. A revised version has been tried there and in several other schools during 1965–66.

Schools interested in cooperating with the UICSM in the experimental trials of new materials are invited to write to the project director.

The basic text materials developed in the first project (1951–1962) are now obtainable from D. C. Heath and Company. An information sheet containing the project bibliography, reports of research activities, and reprints of articles describing the activities of the UISCM are available from the project director.

42. Experimental Teaching of Mathematics in the Elementary School. PATRICK SUPPES, Institute for Mathematical Studies in the Social Sciences, Stanford University, Stanford, Calif. 94305. (1959–)

In the first years of this project, the aim was to develop a modern mathematics curriculum for grades 1–6 which would provide a richer content by not restricting the curriculum to arithmetic. This general program, which has also been supported by the Carnegie Corporation of New York, led to the elementary-school mathematics series, *Sets and Numbers.* A closely related project on the teaching of mathematical logic to talented fifth and sixth graders was completed in 1963. The textbook, *First Course in Mathematical*

Logic, which has resulted from this work is now available.

The main project effort is presently devoted to the development of a computer-based laboratory for the experimental teaching of elementary-school mathematics. A computer-based curriculum for grade 1 is now complete. A substantial part of the curriculum for grades 2 and 4 has been prepared as well as a supplementary course in mathematical logic. During the academic year 1965–66 these materials were tested in the laboratory; during 1966–67, testing will take place through specially installed facilities in a public elementary school. Behavioral data on the results are being made available. The system is so constructed that fairly elaborate terminal equipment permits a rich variety of auditory and visual stimuli to be presented to the individual student. Each student is permitted to work at his own pace and is able to use several devices for responding, including a standard typewriter keyboard. The project is particularly concerned with investigating the extent to which accommodation to individual differences permitted by using the computer in a time-sharing mode will facilitate the learning of elementary-school mathematics. The program in mathematical logic permits the student to analyze the problem, indicate to the computer what rule is to be applied, and then wait for the computer to do the routine job of writing out the resulting new line of the proof. The computer program will accept any valid inference by the student regardless of whether or not it was a wise step in finding a proof. When an invalid step is proposed the computer program rejects it and gives a reason for its invalidity. A similar computer program in elementary geometry and drill-and-practice materials for supplementary arithmetic instruction are also under preparation.

P. Suppes and Rose Ginsberg, "A Fundamental Property of All-or-None Models, Binomial Distribution of Responses Prior to Conditioning, with Application to Concept Formation in Children," *Psychological Review* 70, 139–161 (1963).

P. Suppes and Shirley A. Hill, "Set Theory in the Primary Grades," *New York State Mathematics Teachers' Journal* 13, 46–53 (1963).

P. Suppes and Shirley A. Hill, *First Course in Mathematical Logic,* Blaisdell Publishing Company (1964).

P. Suppes, "The Ability of Elementary-School Children to Learn the New Mathematics," *Theory Into Practice* 3, 57–61 (1964).

P. Suppes, "Modern Learning Theory and the Elementary-School Curriculum," *American Educational Research Journal* 1, 79–94 (1964).

P. Suppes, "The Formation of Mathematical Concepts in Primary-Grade Children," in A. Harry Passow and Robert R. Leeper (eds.), *Papers from the ASCD Eighth Curriculum Research Institute,* 99–119 (1964).

P. Suppes and F. Binford, "Experimental Teaching of Mathematical Logic in the Elementary School," *The Arithmetic Teacher,* 187–196 (1965).

Revised editions of *Sets and Numbers for Grades K–6,* L. W. Singer Company (1965).

43. Cambridge Conference on School Mathematics. William Ted Martin, Department of Mathematics, Massachusetts Institute of Technology. (Grantee: Educational Services Incorporated, 55 Chapel Street, Newton, Mass. 02158.) (1963–)

The aims of this project have been to encourage intensive study and discussion among mathematicians and scientists relating not only to the present content, structure and sequence of mathematics curricula in the schools, but also to the determination of alternative long-range goals in the teaching of mathematics in the schools and in the education of teachers. A conference held during the summer of 1963 resulted in the publication of *Goals for School Mathematics: The Report of the Cambridge Conference on School Mathematics,* which summarized the views of participating mathematicians. This report has been the topic of discussion at several national and regional meetings and among mathematicians and curriculum development groups in mathematics throughout the nation. Following the 1963 conference, the project has conducted a number of conferences and experimental classes concerned with materials contained in the report and participated in activities designed to stimulate further work. In March 1965, a three-day conference sponsored jointly by the School Mathematics Study Group and the Cambridge Conference was attended by representatives of the major curriculum reform groups in mathematics in the United States. Its main purpose was to establish better communication between the various individuals and groups concerned with educational reform in mathematics.

A small workshop during summer 1965 prepared broad outlines together with exercises and examples for possible text material for the primary grades in the areas of geometry, applications, and circular functions in preparation for calculus. The material produced on these three topics is intended to serve as a basis for text materials either by other writing groups or by commercial publishers. Teacher education was the topic of a larger conference to be held during the summer of 1966. This conference considered and developed suggestions regarding the education of mathematics teachers, and studied the implications for teacher training of the report of the 1963 conference. A report of the 1966 conference is being prepared.

Materials available from Educational Services Incorporated (Box 415, Watertown, Massachusetts) include summary reports of the March 1965 conference; general descriptions and reprints of journal articles on the work and plans of the Cambridge Conference; collected reports on experimental curriculum work carried on by individual members and during summer 1965; *ESI Quarterly Report,* Spring-Summer 1966; and *Goals for School Mathematics: The Report of the Cambridge Conference on School Mathematics,* Houghton Mifflin Company (1963).

44. Survey of Recent East European Literature in School and College Mathematics. *(Elementary, Secondary, College).* ALFRED L. PUTNAM and IZAAK WIRSZUP, Department of Mathematics, The University of Chicago, Chicago, Ill. 60637. (1956–)

The Survey is accumulating a representative library of mathematics textbooks, books, periodicals, pamphlet series, resource materials, syllabi, and course programs. It is translating and adapting some of the best materials from these East European sources, particularly the Soviet Union, for use by teachers and students as supplements to the formal curriculum in schools and colleges and in teacher education programs. From the Survey Library (one of the largest collections of materials of its kind outside the Library of Congress) a more comprehensive sampling of the mathematical literature is being prepared in the form of excerpts translated from publications in various categories. A further aim of the Survey is to study research and experiments relevant to mathematics education in East European countries and to report these findings to all interested groups in the United States. Currently, the Survey is reviewing the extensive Soviet research literature in the psychology and methodology of learning and teaching mathematics. Selected materials are being translated and publication is planned in cooperation with the School Mathematics Study Group. (See Item 40).

A series of booklets, "Topics in Mathematics" (from the Russian series "Popular Lectures in Mathematics"), is published by D. C. Heath and Company: *Algorithms and Automatic Computing Machines* (Trakhtenbrot), *Areas and Logarithms* (Markushevich), *Computation of Areas of Oriented Figures* (Lopshits), *Configuration Theorems* (Argunov, Skornyakov), *Equivalent and Equidecomposable Figures* (Boltyanskii), *The Fibonacci Numbers* (Vorobyov), *How to Construct Graphs* (Shilov) with *Simplest Maxima and Minima Problems* (Natanson), *Hyperbolic Functions* (Shervatov), *Induction in Geometry* (Golovina, Yaglom), *Introduction to the Theory of Games* (Venttsel'), *The Method of Mathematical Induction* (Sominskii), *Mistakes in Geometric Proofs* (Dubnov), *Proof in Geometry* (Fetisov), *Summation of Infinitely Small Quantities* (Natanson), *What is Linear Programming?* (Barsov).

In addition, several Russian mathematical textbooks have been translated in full and published by D. C. Heath and Company: *Convex Figures and Polyhedra* (Lyusternik), *Eight Lectures on Mathematical Analysis* (Khinchin), *Geometric Construction in the Plane* (Argunov, Balk), *Infinite Series* (Markushevich), *Geometry of the Straightedge and Geometry of the Compass* (Zetel'), *Isoperimetry: Maximal and Minimal Properties of Geometric Figures* (Kryzhanovskii), *Multicolor Problems* (Dynkin, Uspenskii), *Probability and Information* (Yaglom and Yaglom), *Problems in the Theory of Numbers* (Dynkin, Uspenskii), *Random Walks* (Dynkin, Uspenskii,).

Information on "Topics in Mathematics" and the books may be obtained from the publisher.

Published by the School Mathematics Study Group (as Vol. IV of Studies in Mathematics) and available from A. C. Vroman Inc., *Geometry* (Kutuzov).

Published by Holden-Day: *Challenging Mathematical Problems with Elementary Solutions,* Vol. I: *Combinatorial Analysis* (Yaglom and Yaglom); and *Challenging Mathematical Problems with Elementary Solutions,* Vol. III: *Various Branches of Mathematics* (Yaglom and Yaglom).

Published by Pergamon Press, available from the Macmillan Company: *Envelopes* (Boltyanskii), *Shortest Paths* (Lyusternik), *Successive Approximation* (Vilenkin), *Systems of Linear Equations* (Margulis).

A number of papers derived from Survey materials have been published in *The Mathematics Teacher* and *The Mathematics Student Journal.* A list is available from the project director.

45. High School Course in Modern Coordinate Geometry. ROBERT A. ROSENBAUM, Provost, Wesleyan University, Middletown, Conn. 06457. (1964–1967)

A textbook, with an accompanying teachers' commentary, for a tenth-year geometry course has been prepared, based on *Modern Coordinate Geometry* (experimental edition, School Mathematics Study Group, 1961). The distinctive feature of the text is the development of affine geometry before Euclidean. Coordinates are used at the outset in a natural way, yielding a body of knowledge unlike that of the traditional high school course but very much like the kind of geometry actually used in subsequent scientific situations.

The text materials were tested in thirty-five classes during 1964–65 and were revised in the light of this experience. Further trial during 1965–66 is expected to result, after minor revision, in a final version by fall 1966.

Further information is available from the project coordinator, Harry Sitomer.

46. Geometry Project. NEWTON S. HAWLEY, Department of Mathematics, Stanford University, Stanford, Calif. 94305. (1959–1963)

The Geometry Project was an experiment in teaching geometry in elementary schools. More than 5,000 students participated in this program. The current text, *Geometry, A Workbook for Reading and Construction,* by Newton S. Hawley, went into use beginning in September 1961.

The material is designed to be used by *all* students and to help the regular classroom teacher give the instruction. Classes have been taught successfully by teachers who have never before studied geometry. Moreover, the geometry is not intended to replace, but to supplement arithmetic. The time required is 15 or 20 minutes a day during a year.

Although the geometry workbooks which were used in this program are no longer available, a brief report may be obtained from the project director.

47. Preparation of Materials for Pre-Limit Calculus. HAIM REINGOLD, Department of Mathematics, Illinois Institute of Technology, Chicago, Ill. 60616 (1965–1967)

A new approach based on earlier work by Dr. Karl Menger of the Illinois Institute of Technology will be developed for teaching calculus in the last year of high school, including a development of the theory of maxima and minima, of rate problems, and of applications of calculus to geometric questions. Materials to be produced will inlude problems and exercises comprehensible and interesting to the beginner in the domain of differential calculus; for example, a selection of extremum problems, of useful and not farfetched problems on related rates of changes, and of questions pertaining to tangents, normals, and curvature of curves. Area and volume problems will be treated as applications of the integral calculus. Graphic and numerical methods will be used to initiate the beginner into the understanding of area and slope problems and reciprocity of area and slope; the limit concept will be introduced after the student has gained a full understanding of the essence of calculus by elementary means.

The problems and exercises to be developed in order to elucidate this approach will be tried out first with high school teachers, and then, through them as well as directly, with high school students. The resulting materials will be made available in manuscript form to interested mathematicians, mathematics educators, and schools.

48. University of Illinois Arithmetic Project. DAVID A. PAGE, Educational Services Incorporated, 55 Chapel Street, Newton, Mass. 02158. (1964–1965)

The University of Illinois Arithmetic Project was begun in 1958 with the support of the Carnegie Corporation of New York. It is currently operating in association with Educational Services Incorporated.

The project is producing course materials in mathematics and its teaching for elementary school teachers. It is concerned with the development of mathematical topics or schemes which offer large numbers of interrelated problems that children can do and which contain significant mathematical ideas. Working with such topics also improves computational skills. The course for teachers is designed for direct inservice use and is intended to be of value even to groups of teachers lacking expert mathematical guidance. The course will include the working of extensive sequences of problems which transmit ideas, and the observation of motion pictures of classroom teaching by a variety of teachers. As part of the preparation of this course, the project is conducting teacher-training institutes in local school systems and assisting in the teacher-preparation program at several of the Massachusetts state colleges. Through its institutes more than 350 teachers in the greater Boston area have been introduced to project topics and have begun to use them in their classrooms. Development of new topics and materials continues; project staff members regularly teach nearly 600 children in schools in Watertown, Wellesley, and Boston. The project is also cooperating with the

Perkins School for the Blind in preparing and adapting materials for use with blind children.

Motion pictures of project classes will be available for general distribution only upon completion of the course; however, films may be borrowed by groups especially interested in seeing samples of the project's work. The project also accepts a limited number of invitations to teach demonstration classes. Inquiries should be addressed to the project director.

Booklets and reprints:

1. *Arithmetic with Frames* (1957, revised 1962).
2. *Do Something About Estimation* (1960).
3. *A First Grade Sample* (1960).
4. "Teaching Creativity in Mathematics," *The Arithmetic Teacher* 8 (March 1961). Reprint.
5. *Ways to Find How Many* (1962).
6. *Maneuvers on Lattices, an Example of "Intermediate Invention"* (1962).
7. "Number Lines for the Orbiting Atomic Teacher," *The Grade Teacher* 79 (April 1962). Reprint.
8. "Well Adjusted Trapezoids," *Updating Mathematics* 4 (1962).

Motion pictures (16mm, black-and-white, sound) available on a limited loan basis:

1. *Three A's, Three B's, and One C* (45 min.).
2. *Graphing with Square Brackets* (25 min.).

49. Syracuse University-Webster College Madison Mathematics Project. Robert B. Davis, Department of Mathematics, Syracuse University. (Grantee: Webster College, Webster Groves, Mo. 63119.) (1961–)

The Madison Project attempts to intervene in the educational process at the level of the child's actual experiences in school, rather than at the level of textbook writing or at the level of stating curricula. Curriculum is one aspect of school experience, but the fully shaped experience goes beyond curriculum, including actions of teacher and student and interactions between them. To give an example, one can list the concepts of average and interquartile range for a finite set of real numbers as a curriculum entry. A classroom experience related to these concepts might be: Four children independently guess the width of the room, and the average and variance for these four numbers are computed. Then four children measure the room width, using 6-inch rulers, and the average and variance of these four numbers are computed. Finally, four teams of children measure the room width using a high-quality surveyor's tape measure, and the average and variance for these four numbers are computed. The meanings of average, variance, interquartile range, etc., are brought out by discussion, but are not stated expositionally by the teacher.

Intervening at the level of actual school experiences is far more difficult than intervening at the textbook or curriculum level, but the effects may be far more important. In order to propagate classroom experiences on a nationwide basis, the project is preparing in-service teacher-training courses based on films showing actual classroom lessons; these films and accompanying written materials are designed to enable teachers to incorporate Madison Project-like experiences into their own classes. The present emphasis is on grades 1–9, plus kindergarten and nursery school, and the subject emphasis is a combination of arithmetic, axiomatic algebra, coordinate geometry, rudimentary study of functions, logic, limit of a sequence, and certain portions of physics.

Available materials include tape recordings, written material and 16mm, black-and-white, sound motion pictures *(First Lesson, Second Lesson, A Lesson with Second Graders, Graphing a Parabola, Guessing Functions, Postman Stories, Circles and Parabolas, Complex Numbers via Matrices, In-Service Course I,* and *In-Service Course II.)* Some films are also available as 8mm cartridges. Closely related materials (not supported by NSF) include: Robert B. Davis, *Discovery in Mathematics,* and *Matrices, Logic, and Other Topics,* both available from Addison-Wesley. For copies of the *Newsletter* and further information, write to: The Madison Project, 8356 Big Bend Blvd., Webster Groves, Mo. 63119.

50. In-Service Films in Mathematics for Elementary Teachers. Harry D. Ruderman, Department of Mathematics, Hunter College High School, 930 Lexington Avenue, New York, N. Y. 10020. (Grantee: National Council of Teachers of Mathematics, 1201 16th Street, N.W., Washington, D.C. 20036) (1963–1966)

The objective of this project was to produce a series of 16mm mathematics films (30 minutes each) in color, to be used for the in-service training of elementary teachers embarking on a new program in elementary school mathematics.

The project has produced ten films, each accompanied by text materials and a teachers' manual for the whole series. Another film is in preparation.

The content of the course is the development of the whole number system, the operations in it and their properties, our common decimal system of numeration, and the usual algorithms. This presentation is consistent with the recommendations of the Committee on the Undergraduate Program in Mathematics of the Mathematical Association of America.

The series is intended for use by institutes for elementary school teachers (summer or in-service), and for study groups of elementary school teachers involved in teaching the newer programs. Negotiations for commercial distribution are under way for sale or rental of the series.

For further information write to James D. Gates, Executive Secretary, National Council of Teachers of Mathematics, or to the project diretor.

51. Foundations of Mathematics for Elementary School Teachers. E. Glenadine Gibb, Department of Mathematics, State College of Iowa, Cedar Falls, Iowa 50613. (Present address: Science Education Center, The University of Texas, Austin, Tex. 78712.) (1962–1966)

The purpose of the 12 thirty-minute films and the text prepared to acompany them is to provide an introduction and orientation to a longer and more intensive in-service program that a school system might wish to use to improve the training of elementary school teachers. Also, it is a program that may be carried out with only minimal use of consultants from colleges and universities. This project has been supported by the National Science Foundation and the State College of Iowa.

Preliminary materials (video tapes, kinescopes, and notes) developed in 1962–63 were used on an experimental basis in several schools in Iowa during 1963–64. In 1964–65 revisions were made of the films and notes, and a consultants' guide was prepared. The titles of the fims are: *What Is a Number?*, *A System of Numeration*, *Operations on Whole Numbers*, *Techniques of Computation*, *Non-metric Geometry*, *The Fractional Numbers: Addition and Subtraction*, *The Fractional Numbers: Multiplication and Division*, *Measurement*, *The Integers*, *Problem Solving*, *Coordinate Systems*, and *Real Numbers*.

A review of the project has been made by J. Fred Weaver, "Foundations of Mathematics for Elementary Schools," *The Arithmetic Teacher* 10, 359 (1963).

Address inquiries to Raymond Schlicher, Director of Field Services, State College of Iowa, Cedar Falls, Iowa 50613.

52. University of Illinois Committee on School Mathematics (UICSM): Films for Training Ninth-Grade Algebra Teachers. *(Secondary, College)* Max Beberman, University of Illinois Committee on School Mathematics, 1210 West Springfield, Urbana, Ill. 61801. (1962–)

UICSM, under the direction of Professor Beberman, is preparing a series of 50 films intended to acquaint teachers with the content of modern secondary school algebra courses and to exemplify pedagogical techniques which have proven effective with such content. The films have been produced for flexible use in pre-service, in-service, or institute training employing either the whole series or selected sub-series. Extensive written materials accompany the films. The film series will become available for purchase or rental early in 1966 and will include the following sub-series:

1. A series of 14 films which trace the developments of concepts and principles which lead to an understanding of equations. The plan is to use this sub-series for a three-week institute or workshop.
2. A 10-film series on operations with real numbers which would be appropriate for a concentrated two-week workshop or for an in-service seminar meeting once a week.
3. A 16-film series on deductive justifications for algebraic manipulation, developing a topic common to all the new mathematics programs. Such a series would be useful for a one-month institute or for a one-semester pre-service course for teachers.
4. A 10-film sub-series on the topic of inequality relations in elementary algebra.
5. 10-film sub-series pertaining to the relation of algebra to its applications.
6. A three-film series on pedagogy.

See Item 41 for a description of the UICSM project.

53. Films for Mathematics Teachers. Paul C. Rosenbloom, Mathematics Section, Minnesota National Laboratory, Minnesota State Department of Education, St. Paul, Minn. 55101. (Present address: Teachers College, Columbia Uiversity, New York, N. Y. 10027). (1960–1961, 1963)

About 210 half-hour films were produced for the in-service education of mathematics teachers. For each of the grades 7–12 a series of about 20 demonstration classes taught with the materials of the School Mathematics Study Group (SMSG) was filmed. Accompanying each series is a set of 14 to 20 lectures for teachers on the mathematics background of new courses for that grade level. There is also a general introductory film on the various recent developments in the mathematics curriculum, and a series of 20 lectures and demonstrations on the psychology of elementary mathematical concepts, directed at elementary school teachers. Also available are homework problems suitable for use with filmed or television courses for pre-service or in-service education of teachers.

For rental or purchase of films write to: Audio-Visual Extension Service, University of Minnesota, Minneapolis, Minn. 55455.

54. Patterns in Arithmetic. HENRY VAN ENGEN, Departments of Education and Mathematics, University of Wisconsin, Madison, Wis. 53706. (1961–1963)

This is a television course conceived to test the idea of teaching arithmetic to teachers and pupils simultaneously. The lessons cover the standard arithmetic program from a modern point of view with enrichment work in geometry and number theory. Lessons 15 minutes in length are offered twice a week. In about 70 lessons per grade, all of the essential theory can be covered. Suggestions for teachers and exercises for pupils sufficient to serve as the basic program for the entire year accompany the television program. *Orientation Programs for the Teacher*, a companion series of ten half-hour telecasts spaced to occur about every three weeks, give an overall view to the teacher of the material to be covered in the following three weeks and the mathematical content of the program for the pupils.

Kinescopes are available for use by other educational television stations, together with workbooks for the pupils and suggestions for the teachers.

55. Programed Correspondence Courses in Algebra and Geometry for In-Service Training of Secondary School Mathematics Teachers. WELLS HIVELY II, Department of Educational Psychology, University of Minnesota, Minneapolis, Minn. 55414. (Grantee: Minnesota Academy of Science, St. Paul, Minn.) (1963–1966)

Two separate courses are being developed, one in algebra and one in geometry. These are intended to provide in-service teachers with the foundations needed to teach any of the newer secondary-school curricula. The courses are programed for self-instruction and designed to be entirely self-contained. Each is approximately equivalent to a three quarter-hour course (about 100 hours of work). The algebra course is now available in preliminary form through the University of Minnesota. Plans are to publish it more generally in 1966, together with detailed data on use with 350 teachers in the upper Midwest. A "semi-final" experimental edition of the geometry course is being tried out by teachers in the upper Midwest during 1965–66. Early in 1967 this course should also become generally available, together with an extensive unit on problem solving currently under development.

A Programed Course in Algebra for Teachers, Ancel C. Mewborn, University of North Carolina, senior author. Semi-final edition available to individuals through the Correspondnce Study Department of the University of Minnesota (3 quarter-hours undergraduate credit, $55).

A Programed Course in Geometry for Teachers, Murray Klamkin, Ford Scientific Laboratories, senior author. Experimental edition, not yet generally available.

Technical reports and articles and further information can be obtained from the project director.

56. Regional Orientation Conferences in Mathematics. FRANK B. ALLEN, Department of Mathematics, Lyons Township High School and Junior College, La Grange, Ill. (Grantee: National Council of Teachers of Mathematics, 1201 16th Street, N.W., Washington, D.C. 20036.) (1960–1963)

In 1960 the National Council of Teachers of Mathematics held a series of Regional Orientation Conferences in Mathematics for school administrators and teachers designed to supply information regarding various new programs in school mathematics. A booklet, *The Revolution in School Mathematics,* based on the experience at these conferences answers many questions concerning the new programs.

For copies of the booklet write to James D. Gates, Executive Secretary, National Council of Teachers of Mathematics.

57. Evaluation of Secondary School Mathematics Curricula. JAMES J. RYAN, Director of Research, Minnesota National Laboratory, State Department of Education, 1821 University Avenue, St. Paul, Minn. 55104. (Grantee: Minnesota Academy of Science, St. Paul, Minn.) (1962–1967)

The evaluation, conducted with experimental classes in Minnesota, Wisconsin, Iowa, and the Dakotas, concerns a comparison of the conventional, School Mathematics Study Group, Ball State, Illinois, and Maryland curricula. The evaluation also involves comparison of the effectiveness of teachers before, during, and after experience with new programs; measurement of effectiveness of two-year sequences; and effects of teacher experiences and of in-service education. New achievement tests have been and are being constructed. Data will be collected for the validation of attitude scales against behavior and for studies of the relation of teacher characteristics to effectiveness. Classroom observers will gather data for analysis of pupil-teacher interaction in the classroom. The purpose is not to evaluate teachers, but to evaluate the effectiveness of curricula under various conditions of use and qualifications of staff.

Further information is in SMSG (School Mathematics Study Group) *Newsletters* No. 2 (out of print) and No. 10 and in bulletins and reports published by the Minnesota National Laboratory.

58. Individual Manipulative Materials for Use in Teaching Elementary School Mathematics. JOSEPH N. PAYNE, University School and School of Education, The University of Michigan, Ann Arbor, Mich. 48104. (1961–1963)

The purpose of the project was to develop manipulative devices that could be used by children to assist in the formation of certain mathematical concepts in the elementary school. The materials developed were used experimentally in mathematics classes in grades K–6 by several hundred pupils. Specific directions for the use of the materials and suggestions for their adaptation to the teaching of given concepts have been prepared.

The following items have been developed:

1. *Strips.* A set of sixty strips made of brown hardboard in multiples of ½" units from ½" through 5". The strips are helpful in learning concepts of number; addition, subtraction, multiplication, and division of whole numbers, linear and area measure; rational numbers, and operations on rational numbers. The cost is $1.50 per set or $1.25 per set in orders of 25 or more.

2. *Unit Strips.* A set of fifty-unit strips, each measuring ½" x ½", used as counters in the primary grades and for multiplication and division of rational numbers in the upper grades and junior high school. The cost is $1.00 per set or 75¢ per set in orders of 25 sets.

3. *Bead Frame and Abacus.* A 10–inch wire, with 20 nylon beads of alternating colors by sets of five beads, inserted in a block of tongue-and-groove mahogany wood. Two or more of the bead wires can be joined for use as an abacus. The bead frame-abacus is useful in developing number concepts, and teaching place value and addition, subtraction, multiplication, and division of whole numbers in the lower elementary grades. Cost per wire is 50¢. In sets of 25 or more, the cost is 80¢ for two wires and $1.20 for three wires.

4. *Hundred Chart.* A printed hundred chart, 10" x 10", with numerals 1 to 100 on one side and 100 circles, grouped by fives, on the other side. The cost is 15¢ per chart or 10¢ in orders of 25 or more.

The materials may be purchased from the Forma Company. Further information may be obtained from the project director.

59. Educational Computer Kit. ARNOLD H. KOSCHMANN, Department of Electrical Engineering, University of New Mexico, Albuquerque, N. Mex. 87106. (Former director, R. K. Moore.) (1959–1963)

The University of New Mexico Educational Computer is a digital computer with an internally stored program; it includes the basic features of modern high-speed digital computers. The memory has a capacity of 384 words consisting of 15 binary digits plus sign bit. Operation is in the binary number system, with provision for octal input and output. The major purpose of the machine is to serve as a vehicle for teaching certain topics in mathematics and physics, as well as for teaching the principles of modern computer operation and programing. Because of its slow speed, the computer is well adapted to educational use but is not well suited to lengthy computation.

Further information can be obtained from the project director.

60. Inexpensive Digital Computers. *(Secondary, College)* ALLEN L. FULMER, Department of Science and Mathematics, Oregon College of Education, Monmouth, Ore. 97361. (1960–1963)

SPEDTAC (Stored Program Educational Digital Transistorized Automatic Computer) is a serial, single address, fixed point, binary-type internally stored program digital computer designed specifically as a classroom and laboratory tool to aid in teaching mathematics and engineering courses. The computer features a non-volatile magnetic disc memory with a capacity of 256 thirteen-bit words, and an average access time of 8.3 msec. A modern teletype printer is utilized for input-output and other types of input-output equipment may also be added.

Further information, including a description of closely related projects (a new and improved Educational Digital Computer, high school pilot programs in computer education, suggested high school course outlines), and sources of commercially available versions of these computers may be obtained from the project director.

61. Formal Deductive and Symbolic Logic Teaching Equipment. *(Secondary, College)* STANLEY J. BEZUSZKA, S. J., Department of Mathematics, Boston College, Chestnut Hill, Mass. 02167. (1961–1963)

This project has developed various mathematical machines and devices including: (1) a classical formal deductive logic machine, (2) a symbolic logic device, (3) circuits to exhibit power sets, (4) base converters, (5) a circuit designed to determine the properties of relations, (6) addition and multiplication devices, and (7) graphing machines.

Further information can be obtained from the project director.

F. Physics (includes Engineering)

For additional projects related to this section see also:

14. Physical Science Study Committee—Introductory Physical Science.

79. Overhead Projection Series of Lecture Experiments in the Sciences.

280. Center for Educational Apparatus in Physics.

289. Films on Superfluidity and Superconductivity.

290. Short Films in Physics.

291. Color Motion Pictures Illustrating Satellite Motion, Gravitation, and Celestial Mechanics.

293. Sourcebook for Demonstration Experiments in Physics.

296. Experiments on Momentum: (A) Loss of Energy in Captive Collisions, (B) Falling Sand on Scale.

298. Laboratory Demonstrations and Experiments in Optics.

311. Apparatus for Demonstrating Simple Harmonic, Circular and Vibratory Motion.

315. Basic Spectrometer.

62. Physical Science Study Committee (PSSC). *(Secondary, College)* JERROLD R. ZACHARIAS, Department of Physics, Massachusetts Institute of Technology, Cambridge, Mass. 02139. (Grantees: Massachusetts Institute of Technology, 1957–1959; Educational Services Incorporated, 55 Chapel Street, Newton, Mass. 02158, 1960–)

The PSSC physics program has developed a textbook; a laboratory guide with new experiments; simplified, low-cost apparatus in kit form; 54 films which set the tone and standards for the course; achievement tests; an extensive library of paperbound books written by distinguished authors on topics of science; and teachers' guides which provide background material and make concrete suggestions for class and laboratory activities. All course materials are available from the commercial sources listed below. The PSSC course consists of four closely interrelated parts. The first is a general introduction to the fundamental physical notions of time, space and matter. This is followed by a study of light, both optics and waves; a study of motion from a dynamical point of view; and a study of electricity and the physics of the atom. The course concentrates on fewer facts than are usually included in an elementary physics course. Considerable time is spent on the stories running through physics which tie together the facts with explanations. The laboratory is an important tool in learning the ideas and is on an equal level with the textbook, class discussions, and films as a means of learning and teaching.

The text *Physics*, laboratory guide, and teachers' guide, published in 1960 have been revised and published in 1965 in a new edition. Four chapters of the text have been extensively reorganized and rewritten, five chapters have been shortened and five have been reorganized or reworded. Homework problems have been thoroughly revised for each chapter on the basis of teacher feedback information. Also, a new type of short problem has been included in the new edition in direct response to teacher feedback. Each of these new problems refers to a particular section of the chapter and uses material only from that section. The problems are identified by a section reference number, and answers are given in the back of the book. The new laboratory guide contains several new experiments. Several old experiments have been reduced to the status of "necessary demonstrations." The teachers' guide has been revised to bring it into conformity with the revised text and laboratory guide.

Further information is available from Educational Services Incorporated.

The textbook *Physics*, laboratory guide, and teachers' guide: D. C. Heath and Co., 1965, 2nd. ed.

Apparatus kits: available from several supply companies.

Achievement tests (3 batteries: the original battery, an alternate battery, and a scrambled version of the original battery): Cooperative Test Division, Educational Testing Service.

PSSC films (each 16mm, sound and black-and-white except as noted), rented and sold by Modern Learning Aids, which also distributes a teachers' guide to the films (principal scientists in each film are indicated): *Time and Clocks,* 28 min., John King; *Long Time Inter-*

vals, 25 min., Harrison Brown; *Short Time Intervals,* 21 min., Campbell L. Searle; *Measuring Large Distances,* 29 min., Fletcher Watson; *Measuring Short Distances,* 20 min., Dorothy Montgomery; *Change of Scale,* 23 min., Robert Williams; *Straight Line Kinematics,* 34 min., E. M. Hafner; *Vectors,* 27 min., Albert V. Baez; *Vector Kinematics,* 16 min., Francis L. Friedman; *Elements, Compounds and Mixtures,* color, 33 min., Iral Johns; *Definite and Multiple Proportions,* 30 min., Robert St. George and Jerrold R. Zacharias; *Crystals,* black-and-white and color, 25 min., Alan Holden; *Behavior of Gases,* 15 min., Albert V. Baez; *Random Events,* 31 min., Patterson Hume and Donald Ivey; *Measurement,* 21 min., William Siebert; *Introduction to Optics,* color, 23 min., E. P. Little; *Pressure of Light,* 23 min., Jerrold R. Zacharias; *Speed of Light,* 21 min., William Siebert; *Simple Waves,* 27 min., John Shive; *Sound Waves in Air,* 35 min., Richard H. Bolt; *Forces,* 23 min., Jerrold R. Zacharias; *Inertia,* 26 min., E. M. Purcell: *Inertial Mass,* 19 min., E. M. Purcell; *Free Fall and Projectile Motion,* 27 min., Nathaniel Frank; *Deflecting Forces,* 30 min., Nathaniel Frank; *Periodic Motion,* 33 min., Patterson Hume and Donald Ivey; *Frames of Reference,* 28 min., Patterson Hume and Donald Ivey; *Elliptic Orbits,* 19 min., Albert V. Baez; *Universal Gravitation,* 31 min., Patterson Hume and Donald Ivey; *Collisions of Hard Spheres,* 19 min., James Strickland; *Elastic Collisions and Stored Energy,* 27 min., James Strickland; *Energy and Work,* 28 min., Dorothy Montgomery; *Mechanical Energy and Thermal Energy,* 22 min., Jerrold R. Zacharias; *Conservation of Energy,* 27 min., Arthur LaCroix and Jerrold R. Zacharias; *Coulomb's Law,* 30 min., Eric Rogers; *Electric Fields,* 25 min., Francis Bitter and John Waymouth; *Electric Lines of Force,* 7 min., Alexander Joseph; *Millikan Experiment,* 30 min., Francis L. Friedman and Alfred Redfield; *Coulomb Force Constant,* 34 min., Eric Rogers; *Counting Electrical Charges in Motion,* 22 min., James Strickland; *Elementary Charges and Transfer of Kinetic Energy,* 34 min., Francis L. Friedman; *E M F,* 20 min., Nathaniel Frank; *Electrical Potential Energy and Potential Difference* (Parts I and II), 54 min., Nathaniel Frank; *A Magnet Laboratory,* 20 min., Francis Bitter and John Waymouth; *Mass of the Electrons,* 18 min., Eric Rogers; *Electrons in a Uniform Magnetic Field,* 10 min., Dorothy Montgomery; *Electromagnetic Waves,* 33 min., George Wolga; *Rutherford Atom,* 40 min., Robert I. Hulsizer; *Photons,* 19 min., John King; *Interference of Photons,* 13 min., John King; *Photo-Electric Effect,* color, 28 min., John Strong; *Matter Waves,* 28 min., Alan Holden and Lester Germer; *Franck-Hertz Experiment,* 30 min., Byron Youtz.

In addition, a film on the subject of energy, momentum, and the conservation laws with Herman Branson, Howard University, as principal, is in preparation.

Science Study Series, a library of paperbound books for outside reading in fields related to the PSSC course (Doubleday and Co., Inc.):

The Neutron Story (Hughes), *Magnets* (Bitter), *Soap Bubbles and the Forces Which Mold Them* (Boys), *Echoes of Bats and Men* (Griffin), *How Old Is the Earth?* (Hurley), *Crystals and Crystal Growing* (Holden, Singer), *The Physics of Television* (Fink, Lutyens), *Waves and the Ear* (Bergeijk, Pierce and David), *The Birth of a New Physics* (Cohen), *Horns, Strings and Harmony* (Benade), *The Restless Atom* (Romer), *Michelson and the Speed of Light* (Jaffe), *The Universe at Large* (Bondi), *Pasteur and Modern Science* (Dubos), *The Watershed* (Koestler), *Accelerators* (Wilson, Littauer), *Water: Mirror of Science* (Davis, Day), *The Nature of Violent Storms* (Battan), *Near Zero* (MacDonald), *Shape and Flow: Fluid Dynamics of Drag* (Shapiro), *Gravity* (Gamow), *Life in the Universe* (Ovenden), *Radar Observes the Weather* (Battan), *Nerves and Muscles* (Galambos), *The Origin of Radar* (Page), *Heat Engines* (Sandfort), *Count Rumford* (Brown), *Cloud Physics and Cloud Seeding* (Battan), *Lady Luck* (Weaver), *Knowledge and Wonder* (Weisskopf), *Mathematical Aspects of Physics* (Bitter), *Faraday, Maxwell and Kelvin* (MacDonald), *Waves and Beaches* (Bascom), *Rutherford and the Nature of the Atom* (Andrade), *Relativity and Common Sense* (Bondi), *Bird Migration* (Griffiin), *Electrons and Waves* (Pierce), *Perpetual Motion* (Stewart), *Sound Waves and Light Waves* (Kock), *A Short History of Chemistry* (Asimov), *Sir Isaac Newton* (Andrade), *Thirty Years that Shook Physics* (Gamow), *Quantum Electronics* (Pierce), *Computers and The Human Mind* (Fink).

63. Physical Science Study Committee—Advanced Topics. *(Secondary, College)* Uri Haber-Schaim, Educational Services Incorporated, 55 Chapel Street, Newton, Mass. 02158. (1962–1965)

The course materials consist of text, teachers' guides, laboratory guide, films, and apparatus kits which go beyond the material in the basic PSSC course. The materials are suitable for use in advanced high school courses and in colleges using the PSSC text for freshman physics courses; they can also be used to supplment regular physics course materials.

Presently available are the following: Chapter A-1, *Angular Momentum;* Chapter A-2, *Relativistic Kinematics;* Chapter A-3, *Speed, Mass and Energy*; Chapter A-4, *Irreversible Processes;* Chapter A-6, *Atoms, Molecules and Nuclei;* Chapter A-7, *Change in Atoms and in Nuclei;* and the corresponding teachers' guides, as well as Laboratory Guide I and apparatus kits for experiments. Also available are the films *Angular Momentum: A Vector Quantity, Time Dilation* and *Ultimate Speed.* Chapter A–5, on statistical mechanics, the teachers' guide for this chapter and tests for the Advanced Topics material are in preparation.

A revised edition is planned of the present chapters and the first edition of Chapter A-5, to be published under one cover late in the fall of 1966. Until then, Chapters A–1 through A–4 and the laboratory guide are available from D. C. Heath and Company, and Chapters A–6 and A–7 from Educational Services Incorporated.

Teachers' guides and films are available from Educational Services Incorporated. Apparatus is supplied by Macalaster Scientific Corporation.

Further information can be obtained from the project director.

64. Harvard Project Physics. GERALD HOLTON, Department of Physics; Fletcher G. Watson and F. James Rutherford, Graduate School of Education, Harvard University, Cambridge, Mass. 02138. (1965–)

Based on the encouraging results of a two-year, small-scale feasibility study underwritten by a grant from the Carnegie Corporation, Harvard Project Physics was initiated in 1964-65, supported by funds from the Carnegie Corporation, the Sloan Foundation, and the U. S. Office of Education. As the project moves into its second year, it is also receiving support from NSF. The purpose of Project Physics is to create a physics course that will be appealing and instructive to a wide variety of students—including those already intent on scientific careers, those who may not go on to college at all, and those who in college will concentrate on the humanities or the social studies. For the last group in particular, it is necessary to show that physics is neither an isolated and bloodless body of facts and theories with merely vocational usefulness, nor a glorious entertainment restricted to an elite of specialists. Rather, it is the intent to present physics as a beautifully articulated, yet always unfinished creation at the forefront of human ingenuity. Thus, while the new course will be centered on a solid introduction to physics, including some of its recent developments, it will have specific features to distinguish it from most existing physics courses. For example, as the occasion arises the text or assignments in a supplementary reader will stress the humanistic background of the sciences: how modern physical ideas have developed, and who the men and women were who made key contributions; the effect which physics has had on other sciences, especially chemistry and astronomy; and the fact that the progress in physics contributes to contemporary technology and in turn is stimulated by it. In context, the course will also touch on scientific methodology as illustrated by specific developments in physics. The project intends to develop not only a text, but the necessary array of supplementary instructional materials: laboratory, films, programed instruction, special readings, teachers' guide, etc. A detailed evaluation of the impact of the course on students is being designed.

Three newsletters describing the project are available. These and newsletters to be published in the future can be obtained by writing to the Executive Director, F. James Rutherford, Harvard Project Physics, Pierce Hall, Cambridge, Mass. 02138.

65. Engineering Concepts Curriculum Project. EDWARD E. DAVID, JR., Bell Telephone Laboratories, Inc., and JOHN G. TRUXAL, Polytechnic Institute of Brooklyn. (Grantee: Commission on Engineering Education, 1501 New Hampshire Avenue, N.W., Washington, D.C. 20036.) (1965–1966)

At a conference held at Cambridge, Massachusetts in August of 1964, it was decided that materials for a high school course in engineering concepts should be developed. Engineering concepts include those ideas that are basic to man-made devices, systems, processes, and structures. Preliminary reports were prepared outlining these concepts in greater detail. During July and August of 1965, a further conference brought these materials to a state for trial at a few selected high schools in the New York area during the 1965–66 academic year. The course, "The Man-Made World," deals with the following subject matter: I. Logic and Computers, concerning the extension of man's mental abilities through logic circuits and computers as well as the handling and processing of information; II. Sensing and Models, dealing with the extension of man's sensory powers and the various means through which we sense our environment, how we go on to measure it, then build mechanical and physical models from which we construct mechanisms to control it; III. Energy, Control, and Design, dealing with the extension of our muscular powers and the control of energy to specific ends. Appropriate experiments and equipment have been designed as an integral part of the course. Future plans include a revision of the course material on the basis of classroom experience now being obtained, and further tryouts in about 30 schools during 1966–67.

Engineering Concepts Curriculum Project—Report No. 1: A Summer Study Report; Report No. 2: Working Papers of the Summer Study Report. Representative text materials, news reports, and further information are available from Newman A. Hall, Executive Director, Commission on Engineering Education.

66. Lecture Table Thermometer and Voltmeter. *(Secondary, College)* WAYNE TAYLOR, Science and Mathematics Teaching Center, Michigan State University, East Lansing, Mich. 48824. (1961–1966)

The thermometer-voltmeter is provided with a 4-foot scale placed in front of a fluorescent lamp. With appropriate settings of the controls, temperature ranges of 5°, 100°, or 1200°C and EMF of 0–2 volts may be spread across the scale.

An interim report is available from the project director.

G. Social Sciences

For additional projects related to this section see also:

85. American Indian Films.
88. Eskimo Art Film.
89. Films on Nepalese Culture for Courses in Anthropology.
319. Focus on Behavior.

67. Social Science Program. ELTING E. MORISON (Chairman, Executive Committee), Masters' House, Ezra Stiles College, Yale University; JEROME S. BRUNER, Professor of Cognitive Psychology (Director, Elementary Project); and MORTON WHITE, Professor of Philosophy (Director, Senior High School Project), Harvard University. (Grantee: Educational Services Incorporated, 55 Chapel Street, Newton, Mass. 02158.) (1963–)

The content of the elementary school course being developed is "Man," his nature as a species, the forces that shaped and continue to shape his humanity. Three questions recur throughout: (1) What is human about human beings? (2) How did they get that way? and, (3) How can they be made more so? The course is divided into five general areas of concentration: Language, Social Organization, Technology, Prolonged Childhood, and Cosmology. Case studies of the African Bushmen, the Netsilik Eskimo, and Baboons are employed to demonstrate concepts of humanness—certain common denominators which exist between even the simplest cultures and the product of modern technological progress. The principal pedagogical technique is that of inquiry—the presentation of concrete data in such a way as to lead children to ask questions on their own.

The high school program has concentrated on developing a curriculum for the tenth grade in social studies. The main theme has been "The Impact of Technology and Science in Nineteenth Century England," with concentration on three specific topics: (1) The development of the steam engine from the beginning of the eighteenth century to the version perfected by James Watt, (2) the industrialization of Manchester, England, as a case study in the impact of technological change on social relations, and (3) the background, content and cultural influence of Darwin's views on evolution and natural selection. Exposing the student to the actual working of the steam engine, to the actual words of Darwin, and to certain key historical documents concerning Manchester, illustrates the many ways in which technological and scientific advance can influence a society.

Course materials have been published in very limited editions for experimental use only, but should become available in final form in 1966. The following films are available for loan or purchase: *Fishing at the Stone Weir* (The Netsilik Eskimo), Part I, 29 min., Part II, 28 min., color-silent (not available for use in the elementary schools); *Corn and the Origins of Settled Life in Meso-America,* Part I, 19 min., Part II, 21 min., color; *Land and Water in Iraq,* 16 min., color; *Archaeology in Mesopotamia,* 16 min., color; *Earliest Writing,* 11 min., color; *Dani People of New Guinea,* 4 loops of 4 minutes each.

For further information write the project directors.

68. Anthropology Curriculum Study Project (ACSP). MALCOLM COLLIER, Anthropology Curriculum Study Project, 5632 Kimbark Avenue, Chicago, Ill. 60637. (Grantee: American Anthropological Association, Washington, D.C.) (1962–)

The principal tasks of the Anthropology Curriculum Study Project have been the definition of the role of anthropology in the high school curriculum and the preparation of materials to fulfill that role. The intention has been to reach the largest number of students rather than advanced students or elective classes. Another concern of the project has been the preparation of materials which would promote the active involvement of students—their active use of data rather than a passive storage of data, and the preparation of material which develops some variety of abilities: observation, speculation, the perception of the implications of data.

Materials are in preparation, revision, and trial use (but not otherwise available). In 1964, the project developed an experimental unit on *Bio-cultural Evolution* designed to serve as the opening unit in a world history course. Materials for the unit consist of 29 readings, individually bound as pamphlets, 16 overhead transparencies, three sets of slides, one slide tape, two tape lectures, nine 8mm cartridge films (on primate behavior and basic genetics), one 16mm film, and four casts of fossil skulls. On the basis of the trial use the materials are being revised and are being tested during 1965–66. The chronological sequel to this material is the unit called *The Emergence of Civiliaztion*. Present revision of this unit will concentrate on the transformation from hunting societies to urban societies in Mesopotamia and Middle America and will increase the raw materials available for direct student observation.

The concepts of the social sciences are powerful instruments of analysis for the working scholar; ACSP material on *Studying Society* will provide an opportunity to test ways of teaching certain of these concepts to students, and will offer several models of how such tools sharpen observation, enrich interpretation, and increase the probability of student insight and discovery. The focus of interest in *Language and Culture* is on ways of presenting an understanding of the role of language in human evolution and the role of language in human interaction: the development which made possible the transition from animal communication to human communication, writing and its implications for human history, and patterning in behavior and in language. Area Studies materials on *Africa, Latin America*, and the *Middle East* aim to dispel commonly held stereotypes and the simplistic views of these areas and make possible a subtler and less ethnocentric understanding. *A Bibliography of Anthropological Material for High School Use* is an annotated bibliography and guide for classroom use. *The Great Tree and the Longhouse* presents historic Iroquois material and analyzes their cultural motifs and social organization. *Kiowa Years* is a narrative account of life in this tribe just before its capture by the U. S. Army. *Kiowa Profile* gives the historical setting and factual details of Kiowa life, of which the richness of detail in these materials allows the students to be observers. It is hoped that these last three titles will start filling the gap in scholarly materials on American Indian groups useful for secondary school years.

Journal articles: Robert G. Hanvey, "Anthropology in the Schools," *Educational Leadership* 22 (5), (1965); Malcolm Collier, "A Question About Questions," *Social Education* (Fall 1965).

Materials available on request from ASCP office in Chicago: *Newsletters; An Anthropological Contribution to the Teaching of State History; Teaching About Ethnocentrism; Bibliography on Anthropology and Education; Raising the Standard of Learning in the Social Studies; Anthropological Societies, Organizations and Periodicals in the U.S.A.; Sources of Financial Assistance for Graduate Study.*

69. Sociological Resources for Secondary Schools.

Neal Gross (Chairman), Graduate School of Education, Harvard University; Robert C. Angell (Director), University of Michigan, Ann Arbor, Mich. 48104. (Former director: Robert Feldmesser, Dartmouth College.) (Grantee: American Sociological Association, Washington, D.C.) (1964–)

The project has two initial objectives: (1) to develop a body of sociological materials that can be used in a variety of secondary-school social studies courses, and (2) to develop a new course in sociology for secondary schools. In both of these endeavors the project intends to incorporate the cumulative findings and the methodological approaches of contemporary sociology. The work is being carried out under the general supervision of a special Committee of the American Sociological Association.

The materials will be in the form of self-contained "episodes," each examining a single topic from the sociological perspective and requiring between one and ten class periods. Although most episodes will include written material as well as charts, filmstrips, and other conventional teaching aids, particular emphasis is being placed upon involving students in the first-hand gathering or manipulating of data, through laboratory experiments, field observations; or exercises in the classification or interpretation of information. Episodes are being designed by sociologists working in close collaboration with secondary-school teachers. About fifteen episodes were tested in selected schools during 1965–66 in the fields of communication and public opinion, conflict resolution, education, the family, large-scale organizations, population, race relations, and religion and science.

70. High School Geography Project. GILBERT F. WHITE (Chairman), Department of Geography, University of Chicago; NICHOLAS HELBURN (Director), P.O. Box 1095, 2450 Broadway, Boulder, Colo. 80302. (Grantee: Association of American Geographers, Washington, D.C.) (1964–)

The High School Geography Project was initiated in September 1961, with a grant from the Fund for the Advancement of Education. Conferences among leading geographers and teachers brought out concepts, understandings, skills, and attitudes which they believed should be developed at the high school level; an *Advisory Paper* sets forth these attitudes in detail. For one year, ten high school teachers were released from their regular teaching assignments to experiment in the development of teaching materials and units of instruction at the ninth- and tenth-grade levels. In addition, twenty teachers cooperated with the Project by reporting on special work in which they were involved. Each teacher was advised by a professional geographer from a nearby college or university. A *Response Paper* discusses the results of the year's work in terms of the classroom application of these fundamental concepts, understandings, skills, and attitudes. *Selected Classroom Experiences* reports in detail some of the class work.

The Project is now designing a course which will present these fundamental ideas, leading the students by inductive methods to discover the concepts for themselves. Two units, one in Urban Geography and one in the Geography of the Fresh Water Resource, have reached the stage of formal classroom trials. Provisional material on the structure of the discipline is being developed and has had preliminary classroom trials. Eight more units are being prepared this year. They will be accompanied by such teaching aids as films and filmstrips, teachers' manuals, tests, maps, overlays, models, suggested exercises and field observations, and supplementary readings. Though the units are planned to fit into an integrated course outline, each unit will be packaged separately to permit individual selection. Six outlines developing a settlement theme, historical geography, social problems, political geography, regional geography, and world patterns and processes are being prepared and will be published in a booklet. Several booklets on aspects of geography teaching not covered in the outlines are planned.

Work materials used by experimenting teachers and units under development are not available for general distribution. An occasional *Newsletter* and selected portions of the *Advisory Paper* and of the *Response Paper* are available from the project headquarters in Boulder. *Selected Classroom Experiences: High School Geography Project*, Clyde F. Kohn (ed.), is available for $1 from the NCGE Publications Center, Illinois State Normal University, Normal, Ill.

Nicholas Helburn, "Improving Communication Between the Teacher and the Geographer: The Role of the High School Geography Project," *Journal of Geography* 64, 149 (1965).

Nicholas Helburn, "Visual Aids in the High School Geography Project," *Audiovisual Instruction* 9, 679 (1964).

Nicholas Helburn, "Progress Report of the High School Geography Project," *Professional Geographer* 17, 14 (January 1965) and 17, 31 (May 1965).

Gilbert F. White, "Rediscovering the Earth," *American Education* 1, 8 (1965).

"High School Course, *Scholastic Teacher* 85, 2–T (December 9, 1964).

71. Film Series: "Spadework for History" *(Secondary, College)*. E. MOTT DAVIS, Department of Anthropology, University of Texas, Austin, Tex. 78712. (1961–1964)

The basic purpose of the series is to present one type of scientific activity, archaeological research in the United States, as it actually takes place—as scholarship, as practical engineering and management in field and laboratory, and in general as one of the many human activities that are integral parts of modern civilization. The aim is to challenge the student who might undertake scientific work—the kind who is both practical-minded and intellectually oriented. The focus of the series is on reservoir salvage archaeology, which provides a forceful example of the close interrelationship between non-scientific matters and scientific research. The first film tells the story for the country as a whole. Each of the other five includes a brief review of the prehistory of one part of the country, and tells how archaeologists go about their work in that area. The six films (16mm, color-sound, 29 min.) can be viewed independently, but are more effective when viewed in sequence. Titles are: *Salvaging American Prehistory, The Woodlands, The Plains, The Desert, Plateau and Pacific, Salvaging Texas Prehistory.*

Film rentals: Film Booking Office, Visual Instruction Bureau, Division of Extension, University of Texas. Film sales: Radio/Television, University of Texas. Television use (educational or commercial): National Educational Television and Radio Center, New York.

III. COLLEGE AND UNIVERSITY PROJECTS

A. Multidisciplinary

For additional projects related to this section see also:

3. Study on Fundamental Processes in Education.
4. Study Conference on Evaluation.
5. "Horizons of Science" Films.
28. Columbia-Lamont Marine Science Films.

72. Seminar to Initiate New Experiments in Undergraduate Instruction. Jack R. Tessman, Department of Physics, Tufts University, Medford, Mass. 02155. (1965–1966)

A two-week seminar, held at Tufts University in September 1965, brought together college and university administrators and faculty members in the fields of English, history, the sciences, and mathematics to discuss and propose new programs for the teaching of the introductory college courses in English, history, and the social sciences, for the graduate training of prospective college teachers, and for student participation in the teaching and learning-by-teaching process. Participants emphasized the importance of actively involving students in the learning process. Working groups proposed specific ways of accomplishing their involvement: by drawing upon students' interests and experiences; by dealing with real and meaningful questions, often necessarily of interdisciplinary character; and by introducing students, at the same time, to the methods and discipline of the various areas. It is proposed to hold additional meetings during 1966, with the expectation that specific new programs will be launched in some colleges and universities in September 1966.

Further information may be obtained from the project director.

73. Introductory Course in Chemistry and Physics. Rosalie C. Hoyt, Department of Physics, and George L. Zimmerman, Department of Chemistry, Bryn Mawr College, Bryn Mawr, Pa. 19010. (1963–1966)

This is a one-year, 12-hour course, planned as an optional replacement for two separate 8-hour introductory courses in chemistry and physics. It is intended primarily for prospective science majors, including premedical students. There are 4 hours of lecture, 1 hour of discussion, and 5 hours of laboratory a week. Some traditional material of the separate courses has been omitted or treated in less depth (e.g., special relativity theory, qualitative analysis) in order to make room for greater emphasis on other topics not normally treated in detail (e.g., very elementary statistical mechanics and thermodynamics, quantum theory of atoms and molecules). Mimeographed notes and supplemental readings in other references are being used in lieu of a textbook. Laboratory apparatus and experiments not traditionally found in first-year courses are being developed (e.g., X-ray diffraction, atomic spectroscopy). Students from this course will be allowed to enter the regular second-year courses in both departments.

The set of lecture notes in use this year is too preliminary for distribution; the notes are being further revised.

74. Conference on the Nature and Purpose of Undergraduate Science for the Nonscience Major. Robert Hoopes, Oakland University, Rochester, Mich. 48063. (1961–1962)

The conference, held at Michigan State University Oakland (now Oakland University) in May 1962, addressed itself to the following question: Given the present state of scientific knowledge, what should we expect undergraduate nonscience majors to learn about science and how should we best arrange things to see that they learn it? Approximately 20–25 outside participants were involved, together with 6–8 Michigan State University Oakland professors and four undergraduates from Oakland and other institutions. Among central topics seriously discussed were: (1) the history-of-science approach; (2) the philosophy-of-science approach; (3) the "integrated" sciences approach; (4) the "case study" approach; (5) the role of the science laboratory; (6) the mathematics component of a science requirement for nonscience majors; (7) the place of behavioral sciences in the so-called "science" requirement; and (8) the appropriate curricular length of the science requirement.

R. Hoopes (ed.), *Science in the College Curriculum* (Oakland University), 211 p.; Oakland University Bookstore.

75. Coordinated Program for Mathematics and Physics Majors in Freshman and Sophomore Years. REV. CHARLES J. LEWIS, S.J., Department of Mathematics, Fordham University, New York, N. Y. 10058. (1962–1964)

The Fordham mathematics and physics departments are collaborating to solve the problem of proper sequence of mathematics and physics courses for majors in either of these disciplines. The first year is devoted to an intensive course in analysis followed by individual study of physics in the summer. During the sophomore year students continue their study of analysis and take intensive courses in mechanics, and electricity and magnetism at the level of sophistication attained in mathematics. Physics majors also enroll in a laboratory course. In the junior and senior years, other courses will be pitched at a correspondingly higher level.

Materials available at present include notes in algebra to supplement the analysis course, notes which briefly explain important physical laws and apply the calculus to problems in physics, and several chapters of a mechanics course for sophomores, which is still being developed. When the program is completed, summary articles will be submitted to the *American Mathematical Monthly* and the *American Journal of Physics.*

76. Development of an Integrated Course in Contemporary Natural Science for Nonscience Majors. FREDERICK REIF, Department of Physics, and RICHARD C. STROHMAN, Department of Zoology, University of California, Berkeley, Calif. 94720. (1965–1967)

This project is for the development of a one-year course designed to give students not majoring in the natural sciences a coherent perspective and appreciation of the fundamental concepts, content, and implications of the natural sciences in the contemporary world. The development of the course is an experimental program on a pilot scale designed to accomplish the following objectives: The course is to be suitable for large groups of students; it will span the disciplines of physics, chemistry, and biology in a unified way; it will encompass a set of lectures and will attempt to enrich these with a carefully selected set of simple demonstration-experiments specifically designed to fit the framework of the course.

Further information will be available from the project directors.

77. Physical Science for Nonscientists. E. A. WOOD (Chairman), Bell Telephone Laboratories, Murray Hill, N. J. 07971; L. G. BASSETT (Director), Department of Chemistry, Rensselaer Polytechnic Institute, Troy, N. Y. 12181. (Grantee: Rensselaer Polytechnic Institute.) (1965–1966)

The primary goal of the project is to design a course which will give the nonscience major an active understanding of the nature of scientific inquiry. A second goal, which is really included in the first, is the training of elementary school teachers so that their point of view will be one of curiosity, confidence, and openmindedness in the handling of science education in the elementary schools. Teachers so trained should be able and eager to make good use of the science materials being produced for elementary schools.

To allow time for the student to explore new concepts and perform experiments unhurriedly, and for the teacher of the course to draw the students out and encourage them to raise questions, the subject matter covered by the course is being severely reduced. The emphasis is on the nature of solid matter and how it is discovered, including an examination of the regularity of solids, their properties and interactions with liquids, melting and freezing, kinetic theory of heat, optical and x-ray diffraction, electrolysis and simple chemical reactions.

The project planned some trial materials consisting of text for the main stem of the course and some kit experiments available for trial in a small group of cooperating colleges and universities during the winter of 1965–66. During the summer of 1966 these materials were modified and "optional packages," discrete units of material that can be fitted into the course at the will of the teacher, were added. In addition to the kit experiments, regular laboratory experiments will be suggested.

78. Establishment of an American Archive of the Encyclopaedia Cinematographica. LESLIE P. GREENHILL, University Division of Instructional Services, The Pennsylvania State University, University Park, Pa. 16802. (1964–1967)

The objective of this project is the establishment of an American Archive of the *Encyclopaedia Cinema-*

tographica at the Pennsylvania State University. Conceived as a scientific encyclopaedia in film form, the *Encyclopaedia Cinematographica* consists of a growing international collection of scientific films of value to university teachers and research workers. Each film in the collection depicts a single phenomenon or type of behavior, and the films are so arranged as to facilitate comparisons of behavior among different species of organisms or comparisons of cultural similarities and differences among cultures. Each film is accompanied by printed materials providing background information. The phenomena recorded on films in the collection have one or more of the following characteristics:

1. They cannot be observed with sufficient clarity by the unaided human eye and, therefore, demand the use of such film techniques as slow-motion or time-lapse cinephotography.
2. They represent phenomena which need to be compared with other phenomena for which verbal descriptions alone are inadequate.
3. They provide documentation of phenomena which occur infrequently, are not otherwise readily available for observation by scientists or students, or which are disappearing from a culture.

Initially, the American Archive will include 742 16mm films, in the following categories: *Biology*—47 Microbiology, 364 Zoology, 9 Botany; *Cultural Anthropology*—107 Africa, 79 Asia, 61 The Americas, 30 Oceania; and *Technical Sciences*—45 Agricultural and Earth Sciences. The collection is growing at the rate of 100 to 120 films a year; additional categories will be added when the supply of good material justifies their inclusion.

Film contributions to the *Encyclopaedia* by American scientists are invited. Films submitted are considered by an international editorial board which has headquarters in Göttingen, West Germany. To be accepted, a film must have a high degree of authenticity and scientific accuracy and must be made by or under the direction of a recognized authority in a specific field. American scientists who are interested in contributing films to the collection are invited to contact the project director.

Films in the American Archive are available on loan for educational and research use from the Audio Visual Aids Library, The Pennsylvania State University; the service charge is $2.50 per film, regardless of length. An index listing the films available in the *Encyclopaedia Cinematographica* collection may be obtained without charge from the project director.

79. Overhead Projection Series of Lecture Experiments in the Sciences. *(Secondary, College)* HUBERT N. ALYEA, Department of Chemistry, Princeton University, Princeton, N. J. 08540. (1960–1966)

The purpose is to develop several thousand lecture experiments to be carried out on the vertical and horizontal stages of an overhead projector.

1. *Chemistry:* Use of vertical stage projector. Over seven hundred experiments described in the Tested Demonstrations series *(Journal of Chemical Education,* 1956–60) have been adapted to overhead microprojection. Special devices have been developed, including one-, two- or three-chamber plastic cells for chemical reactions; a cell for electrical measurements, including electrolysis, electroplating, conductivity, ion migration, and e.m.f.; gas generators; heating devices; a device to convert the vertical stage of the projector into a horizontal stage for showing crystallizations and reactions on the surface of liquids; and devices for measuring electricity, time, volume, weight, temperature, and pressure. Dozens of special devices have been developed, including a polarizer, a cell for demonstrating pH, a delicate balance, etc. For the beginning teacher a kit has been described comprising thirteen basic devices, two projectors, and 100 chemicals (costing $15) with which 300 different experiments can be carried out. Series of experiments in biochemistry and radiochemistry are being developed.
2. *Physics:* Use of both horizontal and vertical stages of the projector. Many of the experiments are suitable for treatment of magnetism, heat, electricity, mechanics, pressure, etc., in physics courses.

Further information: Details of this project as it relates to chemistry are being published monthly in the *Journal of Chemical Education.* Complete information as of September 1965 on the basic kit of devices, projectors and chemicals, together with addresses of suppliers of these items, and over 200 microchemical projection experiments is available from the *Journal of Chemical Education* in a reprint booklet entitled *TOPS in General Chemistry* (2nd ed.) by Hubert N. Alyea.

Many of the experiments published in this series are suitable for physics classes. Additional physics experiments were published in *The Science Teacher* magazine during 1963 under the title "TOPS at Century-21 Exposition."

80. Memo-Activity Camera. H. G. THUESEN, School of Industrial Engineering and Management, Oklahoma State University, Stillwater, Okla. 74075. (1961–1962)

The memo-activity camera has been designed to obtain sequenced photographs of situations to be studied. The camera, through an interval timer and mechanism, records on each exposed 16mm frame the absolute time at which the event occurred. Frames may be exposed at intervals of 0.005 min., 0.04 min., 0.2 min., 1.0 min., 2.0 min., or at random intervals. The camera should be useful in both instruction and research, particularly in industrial engineering and management, as well as in areas such as microbiology, traffic and highway engineering, statistical analysis, psychology, sociology, and business administration.

Copies of the final report are available from the project director.

81. Equipment for Producing Stereograms. *(Secondary, College)* DAVID D. DONALDSON, Howe Laboratory of Ophthalmology, Harvard University Medical School, Boston, Mass. 02214. (1961–1965)

An instrument is being built which can automatically reproduce in diagrammatic form a pair of stereoscopic drawings of an object. The drawings thus produced can be presented to the student either by means of the stereoscopic viewer or by stereoscopic projection. The equipment will consist of (1) a scanner which will determine the contours and shape of the object, (2) an equation solver or analog computer which will analyze the data, and (3) a plotter which will record the final data in the form of three-dimensional drawings.

Further information can be obtained from the project director.

B. Agriculture

82. Commission on Education in Agriculture and Natural Resources (formerly Committee on Educational Policy in Agriculture). RUSSELL E. LARSON (Chairman), Dean, College of Agriculture, The Pennsylvania State University; RICHARD E. GEYER (Executive Secretary), National Academy of Sciences-National Research Council, 2101 Constitution Avenue, N.W., Washington, D.C. 20418. (Grantee: National Academy of Sciences-National Research Council.) (1962–)

This Commission is reviewing trends in education in the agricultural sciences, with a view toward stimulating discussion, re-evaluation and improvement in undergraduate courses and curricula, and toward preparing recommendations for the development of academic programs in the future. Special attention is being given to the preparation in the biological sciences for students enrolled in undergraduate agricultural curricula. Another goal is to stimulate and assist in the development of the agricultural aspects of general education, especially, but not exclusively, general biological education, at all educational levels.

The Commission's present program consists primarily of the following: (1) a series of conferences and special studies, some of which are concerned with undergraduate education in areas within agriculture, such as the animal sciences, plant sciences, and agricultural economics; (2) study groups which are exploring certain areas, including natural resource science, the role of agriculture in general education, and preparation in the physical sciences, and mathematics for students majoring in agriculture; (3) select panels, which visit agricultural colleges to examine their teaching programs in detail. The primary purpose of these visiting panels is to obtain first-hand information about the current situation, major trends and the success of new developments in courses and curricula in agriculture, so that the Commission's activities and reports might better take into consideration existing conditions across the country. A secondary purpose is to assist the individual colleges in self-evaluation and improvement; and (4) a series of position papers and other publications relating to major trends, issues, and problems in undergraduate education in the agricultural sciences. Three of these publications are: "Trends and Issues in Education in the Agricultural Sciences," "The Agricultural Sciences," which describes the Commission's views on the nature of the agricultural sciences, and a publication concerned with technician training.

A list of position papers, statements, conference reports, and other publications, as well as additional information on the work of the Commission, are available from the Executive Secretary.

C. Anthropology

For additional projects related to this section see also:

67. Social Science Program.
68. Anthropology Curriculum Study Project (ACSP).
71. Film Series: "Spadework for History".

83. Visual Anthropology—Motion Pictures as Applied to Research and Teaching. J. O. BREW, Director, Peabody Museum, Harvard University, Cambridge, Mass. 02138. (1959–1963)

A course has been developed in "Representational Methods in Anthropology" to introduce students to the use of light and sound; each member of the course makes a motion picture. Films include *Orange and Blue,* a film on the University of Pennsylvania's excavation at the prehistoric Mayan site of Tikal, Guatemala, and one on the famous Neolithic Bronze and Iron Age rock carvings in Camonica Valley, Italy.

Experimentation and production involving more than 500,000 feet of 16mm color film taken during eight expeditions to Southwest Africa (1950–1959) have continued. The film shows a large part of the culture of the !Kung Bushmen as well as considerable additional material on other Bushman groups for comparative purposes. The comprehensive nature of this reservoir will make it possible to develop a series of film sequences which will permit a course instructor in anthropology to present something approaching actual field experience to his students.

A film has been produced about a group of completely unacculturated native villages in the Grand Valley of the Baliem in the central mountain area of Western New Guinea. The focal institution in Dani society is organized warfare with traditional enemy groups, and it is with aggression and its consequences that the film is primarily concerned. The film follows exactly the course of events as they transpired during the time the 1961 Peabody Expedition was in the field, and shows for the first time, to the best of the director's knowledge, primitive warfare with detail and authenticity.

A description of the film course is available from the Department of Anthropology, Harvard University. Inquiries on the course and the films may be addressed to the project director or to Mr. Robert Gardner, Director of the Peabody Museum Film Study Center, Harvard University.

84. Educational Resources in Anthropology. DAVID G. MANDELBAUM, Department of Anthropology, University of California, Berkeley, Calif. 94720. (1959–1962)

The project included a general survey of the teaching of anthropology and the compilation of bibliographic and other materials for use in college teaching. Fifty-three papers representing the proceedings of a series of ten conferences on anthropological teaching have been published as memoirs 94 and 95 of the American Anthropological Association, 1530 P St., N. W., Washington, D. C. 20005, and in a trade edition by the University of California Press, Berkeley.

D. G. Mandelbaum, G. W. Lasker, and Ethel M. Albert (eds.), *The Teaching of Anthropology.* Memoir 94 (American Anthropological Association, 1963). Forty-six papers grouped in parts as follows: The Undergraduate Curriculum in Anthropology; The Teaching of Physical Anthropology; The Teaching of Cultural and Social Anthropology; Anthropology Courses on Regions and Civilizations; The Teaching of Archaeological Anthropology; The Teaching of Linguistics in Anthropology; The Teaching of Applied Anthropology; Graduate Training in Anthropology; Interdisciplinary Relations in Teaching Anthropology.

D. G. Mandelbaum, G. W. Lasker, and Ethel M. Albert (eds.), *Resources for the Teaching of Anthropology.* Memoir 95 (American Anthropological Association, 1963). Seven contributions, as follows: A Survey of Catalog Listings in Anthropology; Student Enrollments and Teachers of Anthropology in California; Personnel Resources: Building the Anthropology Department; The Use of Audio-Visual Teaching Aids; Teaching Aids in Physical Anthropology; Library Problems in the Teaching of Anthropology; A Basic List of Books and Periodicals for College Libraries.

85. American Indian Films. *(Elementary, Secondary, College)* WILLIAM BASCOM, Robert H. Lowie Museum of Anthropology and Department of Anthropology, University of California, Berkeley, Calif. 94720. (Former Director: S. A. Barrett.) (1961–)

The project has had for its purpose the recording of the arts, crafts, ceremonies, and rituals of the Indian tribes of Western America in color motion pictures and with sound recordings. These records of rapidly vanishing customs will be most useful in research and teaching in many disciplines in addition to anthropology. Such films transform the classroom into a laboratory and provide students with an opportunity for direct, personal observation, something quite impossible under the changed conditions of life in Indian villages today.

Where a custom is still in use, it is recorded in detail as found. However, it is often necessary to reconstruct some old process which is no longer used but which is recalled in detail by some very old tribesman. Days, or even weeks, were spent procuring the authentic materials, and many hours were required for photographing the reenactment of the process itself. Often, this information and reenactment come from the sole survivor who knows all the details of the subject. The film preserves such lore that would otherwise be lost and provides a permanent record available to anyone who wishes to study it.

From the films and tapes recorded in the field, fourteen 16mm sound-color films have been produced for use as teaching aids in college, secondary, and elementary school classes. These include: *Basketry of the Pomo: Introductory Film* (30 min.); *Basketry of the Pomo: Techniques* (32 min.);*Basektry of the Pomo: Forms and Ornamentation* (21 min.); *The Wooden Box: Made by Steaming and Bending* (33 min.); *The Sinew-Backed Bow and Its Arrows,* as made by the Yurok Indians (24 min.); *The Game of Staves,* as played by the Southwestern Pomo Indians of California (10 min.); *Acorns: Gathering, Storing, and Processing,* as done by the Southwestern Pomo Indians of California (28 min.); *Buckeyes: A Food of the California Indians* (13 min.); *Pine Nuts: A Food of the Paiute and Washo Indians of California and Nevada* (13 min.); *Kashia Men's Dances: Southwestern Pomo Indians* (40 min.); *The Totem Pole* (26 min.); *Women's Dances: Dream Dances of the Kashia Pomo* (30 min.); *Obsidian Point Flaking* (13 min.); *Calumet: The Pipe of Peace* (23 min.); and *The Beautiful Tree: Chisk-Kale* (22 min.).

Shooting of additional subjects has been completed. All film and sound materials are at present being organized, documented, and coordinated with field data in preparation for archiving at the Robert H. Lowie Museum of Anthropology. Here they will be preserved for future scientific and educational use.

Produced films are available for rental or sale to any institution or organization, where no admission is charged for their showing, through the University Extension Media Center, University of California, Berkeley.

86. Historic Films on Amerindian Ethnology.

FREDERICK J. DOCKSTADER and CARMELO GUADAGNO, Museum of the American Indian, Heye Foundation, Broadway at 155th Street, New York, N. Y. 10032. (1961–1962)

The primary objective of this project was to preserve specific documentary motion and still pictures on the ethnology of American Indians by transferring perishable negatives to safety film. The films record technologies, ceremonies, and other aspects of the lives of a number of tribes, particularly of the Plains and the Southwest. In most cases, the films were taken during the period from 1919 to 1925; consequently, they often record events which are no longer directly accessible.

Technologies and ceremonies of the Zuñi Indians of New Mexico are shown in 11 films, some of which are suitable for college and advanced study and others are of possible use at any level. The completed films include two of the Crow Indians of Montana and one of the Shoshone Indians of Wyoming. All films are silent, in black-and-white, and vary in length from 5½ to 28 minutes.

Descriptive listings of films available for loan and still pictures and color transparencies for purchase may be obtained from the Museum.

87. Film on Archaeological Findings at La Venta, Mexico.

ROBERT F. HEIZER, Department of Anthropology, University of California, Berkeley, Calif. 94720. (1962–1963)

The unique significance of an ancient Olmec site is communicated in a film, *The Excavations at La Venta* (16mm, color-sound, 29 min.), based largely on the last of three archaeological studies conducted there. At La Venta, in 1955, evidence of the earliest high civilization in Mesoamerica was uncovered. This ceremonial center, placed at approximately 800 B.C. by radiocarbon dating, predated by several hundred years any previously known religious center of comparable development. The site also stands as the most fruitful source of information concerning the mysterious Olmec culture.

The film shows the progress of the excavations, revealing the methods of digging, the symmetrical design of La Venta, its sophisticated stone carvings, and a wealth of jade and other dedicatory offerings which had been ritually buried. Artifacts removed during the 1955 excavations to Mexican national repositories escaped the fate of the main site, which was accidentally obliterated shortly thereafter. The film was made from a small amount of motion picture footage taken in 1955 and some 800 adroitly edited color transparencies, aided by some animation.

Film rental and purchase: University Extension

Media Center, University of California, Berkeley, Calif. 94720.

88. Eskimo Art Film. EDMUND CARPENTER, Department of Anthropology, San Fernando Valley State College, Northridge, Calif. 91326. (1963–1964)

This project proceeds on the assumption that many thoughts and experiences, especially in non-literate societies, lend themselves best to translation into physical projections rather than into words. Aboriginal Eskimo art was chosen as an initial subject, for it defies conventional modes of description and display. The film will be available in both 35mm and 16mm format.

Art to the Eskimo is not an object but a way of being in relation to life. A carver holds unworked ivory in his hands, turning it this way and that, whispering "Who are you? Who hides there?" and then "Ah, Seal!", and he releases the hidden form, always letting the ivory speak. Then, the piece is discarded or, with even greater indifference, simply lost.

Dorset Period (800 B.C.-1300 A.D.) ivory effigies are often so detailed one can tell species, even subspecies, yet so minute that many details escape the naked eye. Some of these details were magnified on film 1000–1200 times. Most lack "verticality" and, hence, have no favored point of view. Many are "visual puns," that is, single designs where every line simultaneously serves several images. Others are "X-ray" carvings. All depict non-Euclidean spatial patterns.

89. Films on Nepalese Culture for Courses in Anthropology. *(Secondary, College)* JOHN T. HITCHCOCK, Department of Anthropology, University of California, Los Angeles, Calif. 90024. (1964–1965)

The purpose of this project was to edit existing film and produce four films in sound and color to be used for the improvement of courses in introductory anthropology. The films were planned as anthropological counterparts of live classroom demonstration in such sciences as physics and chemistry. As in such demonstrations, the aim was to bring the student closer to the total experience of science.

Titles of the completed films are: *Fieldwork in Social Anthropology* (45 min.); *Himalayan Farmer* (22 min.); *Himalayan Shaman of Northern Nepal* (16 min.); These films form a trilogy, all using footage from the same region near the high Himalayas. *Fieldwork* shows aspects of fieldwork, including the search for a transhumant group, method of obtaining entrance into the community, manner of life while there, and various field techniques. *Farmer* shows a difficult daily routine. It is an aspect of the group's ecological adaptation which is a "cultural trap" and suggests why the people are transhumant. *Shaman (North)* shows how these people make contact with the supernatural through a Siberian-type shaman. *Shaman (South)* was made in a lower region closer to India. Though spirit possession is part of the shaman's technique, his methods also show the influence of traditional Hindu practice. The project will conclude with the writing of teachers' guides to develop further the ethnographic context and suggest leads for discussion.

90. Museum of Man: Basic Slide Collection for Antropology Courses. JACK CONRAD, Department of Sociology and Anthropology, Southwestern at Memphis, Memphis, Tenn. 38112. (1960–1961)

Museum of Man is a collection of 300 color slides (35mm) in cardboard mounts, designed to facilitate the teaching of college anthropology courses. For the most part, the slides show artifacts and displays found in major American museums. A 120-page descriptive catalog accompanying the set provides basic information about each slide. The collection contains 25 slides in each of the following twelve areas: *Symbol Systems, Tools and Devices, Food and Drink, Clothing and Ornamentation, Social Organization, Social Control and Social Relations, Religious Systems, Functions of Religion, Religious Masks, Plastic Arts, Musical Arts,* and *Functions of the Arts.*

The collection is available, as a complete set only, from the Bureau of Audio-Visual Instruction, University of Wisconsin, 1312 West Johnson Street, Madison, Wis. 53706.

91. Kinship Models. EDWARD A. KENNARD, Department of Anthropology, University of Pittsburgh, Pittsburgh, Pa. 15213. (1961–1965)

Three types of graphic devices for teaching principles of kin groups, marriage systems, and kinship systems were constructed: a ball and stick three-dimensional device, an electric board model, and a magnetic board model. The devices illustrate systems most frequently utilized in eight widely-used textbooks.

A final report is available from the project director.

92. Graphic Aids for Basic Anthropometry. R. F. G. SPIER and DALE R. HENNING, Department of Sociology and Anthropology, University of Missouri, Columbia, Mo. 65202. (1961–1962)

The objective of this project was to help give anthropology students and interested amateurs a basic knowledge of anthropometric technique. The project has developed: (1) exact bone reproductions, in unbreakable plastic, with measurement points clearly marked, and accompanying desk-and wall-charts indicating measurements to be taken; (2) color slides depicting actual measurement of skeletal materials; and (3) inexpensive, but reasonably accurate anthropometric instruments.

A report on the project is available from the Missouri Archaeological Society, 15 Switzler Hall, University of Missouri.

D. Biology

For additional projects related to this section see also:

27. Oceanography——Eight Narrated Filmstrips.
28. Columbia-Lamont Marine Science Films.
29. Biological Sciences Curriculum Study (BSCS).
30. Television Course on "The New Biology".
31. Films on the Nature of Viruses.
32. Three Educational Films on Myxomycetes.
33. "Living Biology" Film Series.
34. Graphic Methods for Teaching Physiology.
35. Plant Growth Chamber.
82. Commission on Education in Agriculture and Natural Resources.
251. Committee on the Undergraduate Program in Mathematics (CUPM).
256. Introductory Course on Probability Matrices and Calculus for Students in the Biological and Social Sciences.
278. Science Teaching Center: College Science.

93. Committee on Educational Policies in Biology. *(Secondary, College)* Howard M. Phillips, President, Birmingham-Southern College, Birmingham, Ala. 35204. (Grantee: National Academy of Sciences-National Research Council, 2101 Constitution Avenue, N.W., Washington, D.C. 20418.) (1954–1959)

Improving College Biology Teaching, NAS-NRC Publication 505 (1957).

Biological Education: A Partial Bibliography, NAS-NRC Publication 518 (1957).

Recommendations on Undergraduate Curricula in the Biological Sciences, NAS-NRC Publication 578 (1958).

Laboratory and Field Studies in Biology, a Source Book for Secondary Schools, teacher and student eds. (Holt, Rinehart and Winston, 1960).

94. Commission on Undergraduate Education in the Biological Sciences (CUEBS). Earl D. Hanson (Chairman), Department of Biology, Wesleyan University; Martin W. Schein (Executive Director), Commission on Undergraduate Education in the Biological Sciences, 1717 Massachusetts Avenue, N.W., Washington, D.C. 20036. (Grantee: The George Washington University.) (1963–)

The Commission on Undergraduate Education in the Biological Sciences is an independent body of twenty-four college and university biologists interested in the improvement of undergraduate biological education. To achieve its objectives it has developed a program of panels, conferences, summer work groups, consultant service to colleges and universities, and publications. Five of the nine panels are concerned with various aspects of course and curriculum improvements; the other four are concerned with college instructional personnel, interdisciplinary cooperation, instructional materials, methods and facilities; and evaluation and testing. Up to September 1, 1966, CUEBS sponsored ten conferences in undergraduate courses and curricula, and additional conferences are now being planned. During the summer of 1965 there were two working groups: a project at Dartmouth College which produced resource materials for teachers of introductory and core courses, and a colloquium on introductory biology at Stanford University, which produced syllabi for introductory courses. The CUEBS publications consist principally of conference reports, panel position papers, and a newsletter *(CUEBS News)*. These publications are available upon request without charge.

The primary concern of the Commission is to help close the gap between the recent major advances in biological research and the content of undergraduate courses in biology. Consequently, the initial emphasis has been on course and curriculum improvement and modernization. Closely associated is the problem of assisting undergraduate instructors in their efforts to keep up with research advances and new biological viewpoints, and also to develop new and more effective instructional materials and methods.

Further information may be obtained from the executive director.

95. An Introduction to Modern Biology ("The Nature of Living Things"). GEORGE WALD, Department of Biology, Harvard University, Cambridge, Mass. 02138. (1960–1963)

This one-year course is designed both for general education and for students continuing in the sciences, including premedical students. The treatment of the lower levels of organization, beginning with elementary particles, builds up to atoms and the periodic system, discusses forces of chemical combination and molecules (specifically those molecules of importance to organisms), and culminates in the macromolecules. Students are introduced early to making molecular models for themselves. After such a structural consideration of macromolecules and viruses, students are sufficiently well prepared to consider the main processes of cellular metabolism: fermentation, respiration, and photosynthesis. With this they proceed to the cell, and from there develop biology as such. Having approached living organisms by this route, all further matters—morphology, genetics, physiology, and evolution—are discussed at the molecular level whenever that is appropriate.

The laboratory begins at once with living organisms and is biological throughout. It includes three weeks' work in microbiology with bacteria and bacteriophage and two weeks of electrophysiology. A laboratory manual has been published.

G. Wald, P. Albersheim, J. Dowling, J. Hopkins, III, and S. Lacks, *Twenty-six Afternoons of Biology* (Addison-Wesley Publishing Co., Inc., 1962). A second edition is in preparation.

96. Laboratory Experiments in General Physiology. SAMUEL R. TIPTON, Department of Zoology, University of Tennessee. (Grantee: American Physiological Society, 9650 Wisconsin Avenue, Washington, D.C. 20014.) (1951–1960)

This is a compilation of selected, tested laboratory experiments in general physiology for college use. The intention is not to provide a complete college laboratory course, but rather to offer selected experiments to supplement or replace standard experiments that may now be in use, thus allowing teachers to compile their own laboratory courses. The experiments have been collected from experienced teachers of general physiology, tested in the class laboratory, and reviewed and edited by a selected committee. The series of experiments, which has had wide circulation and use since its issuance in 1960, is undergoing revision by physiologists who are active in specialized research fields so that the series will continue to incorporate significant advances in various areas of physiology.

For further information and mimeographed copies of experiments write to Ray G. Daggs, Executive Secretary, American Physiological Society.

97. Laboratory Experiments in Elementary Human Physiology. CHARLOTTE HAYWOOD, Department of Physiology, Mount Holyoke College, South Hadley, Mass. 01075. (Grantee: American Physiological Society, 9650 Wisconsin Avenue, Washington, D.C. 20014.) (1961)

This is a set of tested experiments applicable to an elementary course in human physiology for college sophomores and freshmen whose background in biology may have come largely from secondary-school experience. The attempt has been to gather experiments which supplement those commonly found in the published manuals. A number of experiments, which are modified versions of those used in more advanced courses, have been included. Experiments on vertebrates other than man are included insofar as they bring out important physiological principles. The limits imposed by a moderate budget are kept in mind, as well as the level of the elementary student. To help teachers who wish to use classic physiological experiments, a few have been listed with references to several available manuals. Certain practical aids are also included to help teachers who are setting up physiology laboratory work of this type for the first time.

For further information and copies of the experiments write to Ray G. Daggs, Executive Secretary, American Physiological Society.

98. Sourcebook of Laboratory Exercises in Plant Pathology. ARTHUR KELMAN, Department of Plant Pathology, University of Wisconsin, Madison, Wis. 53706. (Grantee: The American Phytopathological Society, 304 Winston Drive, Ithaca, N.Y. 14850. (1959–1966)

This sourcebook project sponsored by the Committee on Teaching of the American Phytopathological Society is designed to serve two purposes: (1) to assemble in an organized fashion the best exercises currently used in teaching plant pathology in the United States, and (2) to stimulate the development of new exercises for use in introductory courses in plant pathology as well as in botany and general biology courses.

In order to expand the scope of the sourcebook, research pathologists with competence in specialized areas were asked to develop new demonstration-or student-participation exercises which illustrate basic concepts in plant pathology and also incorporate recent significant advances in this area of biology. The first draft, containing 207 exercises with appropriate indices and supplemental material, was released for trial and review in May 1962. A revised version, modified as a result of classroom trial, will be made available in printed form in 1966.

99. Guidebook for Introductory College Courses in Mycology. *(Secondary, College)* RUSSELL B. STEVENS, Department of Botany, The George Washington University, Washington, D.C. 20006. (Grantee: Mycological Society of America, c/o U.S. Army Natick Laboratories, Natick, Mass. 01762.) (1963–1966)

A committee of the Mycological Society of America, with the help of colleagues, is preparing a reference guidebook in introductory mycology. It is not intended for use as a laboratory manual, nor will it be a compilation of laboratory exercises for use in mycology courses. Rather, it is to be a comprehensive assemblage of data and suggestions to help the instructor in devising a balanced and stimulating course. It will tell him how and where to get the fungi he needs, how to maintain them in the condition he wants, and how best to use them in his classroom and laboratory. In addition, there will be data and suggestions on how to use fungi in dealing with problems in genetics, ecology, physiology, and related biological specialities. Some attention will be given to fungi of medical and industrial significance.

A provisional mimeographed edition will be tested by graduate students specifically selected for this task by mycologists who are teaching in colleges and universities.

100. Laboratory Course in Instrumentation. K. S. LION, Department of Biology, Massachusetts Institute of Technology, Cambridge, Mass. 02139. (1960–1966)

The general objective of this project is the development of a broad, thorough, and efficient laboratory course in instrumentation and physical research methodology. The course is designed for graduate and postgraduate students in the biological and medical sciences, but is also suitable for students in the physical sciences and engineering. It begins at an elementary level with the design of simple electric circuits and leads through a sequence of carefully selected classical and modern methods of electric systems and computers. Provisions are made to use the same equipment in intensified summer seminars for research workers and instructors who either want to become familiar with modern instrumentation or who would like to install similar courses in their institutions.

A course description, including laboratory notes for students, will be compiled at the end of this project and made available as a technical report to the scientific community. Visitors are invited to inspect the laboratory.

101. Laboratory Exercises for the Study of Forest Microclimates. F. W. WOODS, School of Forestry, Duke University, Durham, N. C. 27706. (1960–1961)

Laboratory exercises have been developed to provide twenty-four to thirty hours of fieldwork for the study of microclimates in forests. The exercises are useful primarily for college teachers with students at an elementary level of ecological perspective. However, the work can easily be modified to meet the needs of advanced students by increasing the complexity of instrumentation. The laboratory manual includes instructions and a list of materials necessary for the construction of towers, outlines the sequence of fieldwork to be performed, and cites instruments to be used for making measurements. It also includes instructions for preparing and reporting exercises, forms for the collection and compilation of data, lists of selected references, sets of leading questions, and a sample exercise.

102. Film Series: "The Promise of the Life Sciences." JOHN B. HOLDEN, Graduate School, U.S. Department of Agriculture, Washington, D.C. 20250. (1960–1961)

In five 16mm, sound, black-and-white films distinguished scientists tell about advances at the frontiers of research in the biological sciences and report spectacular gains in the broad range of the life sciences. The films, each approximately 50 min. in length, are: *Biological Transformation of Energy,* A. Szent-Györgyi; *Genetics,* George Beadle; *Nutrition—The Chemistry of Life,* Jean Mayer; *Fine Structure and Pattern of Living Things,* Paul Weiss; and *The Organism and the Environment,* Arthur D. Hasler.

Marguerite Gilstrap (ed.), *Promise of the Life Sciences* (Graduate School, U.S. Department of Agriculture, Washington, D.C., 1961, 77pp.), supplements the films. Videotapes have been made available to the National Educational Television and Radio Center, New York.

Film purchase or rental: Graduate School, U. S. Department of Agriculture; also available from the following film libraries: Visual Aids Bureau, University of Arizona, Tucson, Ariz. 85700; Department of Visual Education, University of California Extension, Berkeley, Calif. 94720; Audio-Visual Service, Colorado State University, Fort Collins, Colo. 80521; Georgia Agricultural Extension Service, Athens, Ga. 30602; School Film Library Services, College of Education, University of Kentucky, Lexington, Ky. 40506; Visual Aids Service, University of Illinois, Champaign, Ill. 61803; University Extension Bureau of Visual Instruction, University of Kansas, Lawrence, Kans. 66045; Audio-Visual Center, Michigan State University, East Lansing, Mich. 48823; Audio-Visual Center, University of New Hampshire, Durham, N. H. 03824; Extension Service, College of Agriculture, South Dakota State University, Brookings, S.Dak. 57007; Audio-Visual Division, State Department of Education, Columbus, Ohio 43215; Division of Extension, Visual Instruction Bureau, University of Texas, Austin, Tex. 78712; Bureau of Audio-Visual Instruction, Extension Division, University of Wisconsin, Madison, Wis. 53706.

103. Plant Science Films. *(Secondary, College.)* JOHN D. DODD, Department of Botany and Plant Pathology, Iowa State University, Ames, Iowa 50010. (1962–1966)

The purpose of this project is to produce a series of short (3 to 10 minutes) motion pictures in the plant sciences. These are "single concept" films in the sense that each one deals with some portion of a laboratory experiment which may be difficult to present directly in the classroom (e.g., zoospore release, growth movements, use of radiotracers, etc.). In addition, these films may be used for review and in self-instructional programs.

The project is a joint activity of the Department of Botany and Plant Pathology and the Film Production Unit at Iowa State University. A Steering Committee, composed of 13 nationally known botanists from various colleges and universities and headed by Dr. Wendell H. Bragonier, Dean of the Graduate College, Colorado State University, provides over-all guidance and counsel.

The films are prepared and edited in 16mm color with sound but are being released by distributors in both 16mm and 8mm forms, with and without sound. They are especially adapted for use as continuous loops in projectors equipped to take cartridges. A brief description of the films, which can supplement the narration, is attached to the storage carton for each film.

Titles of the ten films which are now available are: *Algal Syngamy* (isogamy in *Chlamydomonas*), *Algal Syngamy* (zygote formation in *Pandorina*), *Algal Syngamy* (oogamy in *Oedogonium*), *Regulation of Plant Development* (coleoptile response in *Zea*), *Photosynthetic Fixation of Carbon Dioxide, Gamete Transfer in the Bryophytes* (the splash cup in a moss), *Gamete Transfer in the Bryophytes* (the splash platform in *Marchantia*), *Liberation of Zoospores in the Alga* (Basicladia), *Liberation of Zoospores in the Alga* (Oedogonium), *Oxygen Liberation by Isolated Chloroplasts* (The Hill Reaction).

The following 17 additional films are in production and will be available soon: *Spore Dispersal in the Fungi* (Coprinus), *Spore Dispersal in Equisetum, Heterothallism in Phycomyces, Pathways of Water in Herbaceous Plants, Pathways of Water in Woody Plants, Liberation of Zoospores in the Alga (Stigeoclonium), Effects of Red and Far-red Lights on Seedling Development, Isolation of Phytochrome, Photochemical Properties of Phytochrome, Effect of Red and Far-red Light on Internode Length, Phototropic Response of the Zea Coleoptile, Early Development of the Root System, Early Development of the Shoot in Quercus, Pollen Tube Growth, Pollen Release in Zea, Pollination in Zea—A Field Technique, Photoperiodism*—The Flowering Stimulus.

The following firms are now distributing the released films: The Ealing Corporation and Modern Learning Aids. Copies in 16mm sound are available for rental from Visual Instruction Service, 121 Pearson Hall, Iowa State University.

A brochure describing the project and the completed films in more detail is available from the project director. An article describing the project has appeared in the publication of the American Science Film Association: *ASFA Notes* 1(5), 1–8 (1965).

104. Developmental Anatomy Films. CLARENCE M. FLATEN, Audio-Visual Center, Indiana University, Bloomington, Ind. 47405. (1961–1966)

This project is producing five college-level unitized, instructional films on the development of the chick embryo. The series will present the developmental anatomy of (a) the heart, (b) the blood vessels, (c) the extra-embryonic membranes, (d) the nervous system and sense organs, and (e) the germ layers and primitive streak.

The films are designed for use in both classroom and laboratory. They will provide demonstration materials for instructors and provide laboratory or library study materials for individual student use. Films will be released in the following formats: 16mm color-sound; 16mm black-and-white, sound; and 8mm color-silent.

The first film, *Development of the Cardio-Vascular System of the Chick: The Heart,* plus correlated 2 x 2 slides and projection transparencies, has been released. For further information on the films and correlated instructional materials write to the project director. For rental, preview, or purchase, write to: Audio-Visual Center, Indiana University.

105. Short Films in Microbiology. *(Secondary, College, Medical School)* Donald M. Reynolds, Department of Bacteriology, University of California, Davis, Calif. 95616. (1959–1963)

Each brief 16mm film emphasizes a single phenomenon or concept. The films are designed to be used in lieu of still projection slides without disturbing the pace or pattern of lectures. In the first series, fifteen films were made from "clips" taken from longer productions by various organizations, and three were prepared by the project. Films currently available are listed below; all are with sound and one to four minutes in length, unless otherwise listed.

The Development of Bacteriophage Plaques; The Life Cycle of a Bacteriophage; Phagocytosis; Rabies in a Human Patient; The Spread of Typhus; Cholera (color); *Clinical Aspects of Chicken Pox—Varicella* (color); *Clinical Aspects of Leprosy* (color); *Clinical Aspects of Tetanus* (color); *Measles (Rubeola) in Children* (color); *Surgical Removal of Lesions in Pulmonary Tuberculosis* (color), (originator of film does not wish it shown to below college level or lay audiences); *Pharmacological Testing of New Antibiotic Agents* (color); *Production of Poliomyelitis Vaccine* (color, 12 min.); *The Effect of Poliomyelitis Virus on Human Epithelioid Cells* (color, 5 min.); *The Life Cycle of the Malaria Parasite* (animation, color, 11½ min.); *Anaphylaxis in Guinea Pigs* (color, 7½ min.); *The Complement Fixation Test* (animation, color, 5 min.); and *The Rumen Ciliate Protozoa* (8–10 min.).

Information on content and use may be obtained from Donald M. Reynolds, Department of Bacteriology, University of California, Davis, 95616. For rental only: R. W. Sarber, Executive Secretary, American Society for Microbiology, 115 Huron View Blvd., Ann Arbor, Mich. 48103. For rental and purchase: University Extension, University of California, Berkeley.

106. Motion Pictures in Developmental Biology. Eugene Bell, Department of Biology, Massachusetts Institute of Technology, Cambridge, Mass. 02139. (1966–)

This series of films in developmental biology will comprise both short silent loops, each devoted to a single principal problem or technique, and full-length sound films. Specialists in embryology will be involved in the planning and production of each film and will perform the experiments that will be filmed. The combination of time-lapse photography and animation is expected to present dramatically, in a form which can be accurately analyzed, the events which take place in four dimensions during embryological development. Provisions have been made for classroom testing of the films during the early stages of the project's activity.

Further information will be available from the project director.

106A. Films for Evolutionary and Population Biology. George A. Bartholomew, Department of Zoology, University of California, Los Angeles, Calif. 90024. (1966–1969)

A set of approximately twelve color-sound films is being produced for use in teaching evolutionary and population biology. The films will be useful individually or as an integrated series. They will present selected samples of the primary biological and geological data relevant to evolutionary and population biology, and then develop and demonstrate the logical processes through which biological principles and relationships can be abstracted from these data. The Galapagos Archipelago, the site chosen for shooting these films, is probably unequalled as a natural laboratory for evolution, each island having a different complement of plants and animals interacting under slightly different conditions. It is the intention of the project to integrate pertinent data from taxonomy, genetics, behavior, and physiological ecology of both animals and plants. Films in the following areas are planned: the Archipelago as a laboratory for evolution and ecology; the ecology of the islands; Darwin, the Galapagos, and the theory of evolution; the Galapagos finches; mechanisms of physiological adaptation; extremes of adaptation; the relation of structure to function; behavioral differences in morphologically similar animals; the species as a biological unit; the invertebrates of the Galapagos; the effects of man on the ecology of the Galapagos; comparison of terrestrial and marine situations; and the annual and seasonal cycles on an equatorial island.

Further information about the films will be available from the project director.

107. Cinephotographic Techniques in Morphology. *(Secondary, College)* R. D. FRANDSON, Department of Anatomy, Colorado State University, Fort Collins, Colo. 80521. (1961–1963)

The film, *The Major Structures of the Brain, A Method of Demonstrating* (16mm, sound-color, 15 min.), shows a method to help students in anatomy gain a three-dimensional concept of the major structures of the brain. The dog brain is used as a representative higher mammalian type. Macroscopic dissections are compared with serial transverse, horizontal, and sagittal sections. A method of sectioning and dissecting three dog brains per group of students is demonstrated. In addition, the following 10- to 15-minute teaching films are planned: *Over-all Orientation of the Brain, The Cerebrum, The Brainstem, The Cerebellum,* and *A Functional Composite of the Central Nervous System.* Work is continuing with cinematography of serial sections of the brain. Additional films on laboratory techniques in biology and various phases of anatomy are being produced in 8mm magnetic sound format.

The Major Structures of the Brain, A Method of Demonstrating, is available in 16mm format from Audio-Visual Service, Student Services Building, Colorado State University. It is also available in 8mm, color, magnetic sound, from the project director.

108. Cinematography of Serial Microscope Sections. S. N. POSTLETHWAIT, Department of Biological Sciences, Purdue University, Lafayette, Ind. 47907. (1964–1965)

A technique has been developed which will permit the photographing of serial sections through a microscope on movie film. Projection of the film at movie speed produces the sensation of movement through a structure, and the viewer obtains a three-dimensional perception of the subject. Single-concept films of plant specimens, commonly used as illustrations in freshman botany courses, will be produced. These include: seeds of corn, kidney bean and castor bean; roots of corn and buttercup; stems of alfalfa and corn; flowers of lily and sweet pea; apical meristems of coleus and onion root; and leaves of alfalfa and corn.

Further information is available from the project director.

109. Film on Predator-Prey Relationships. FRANK A. PITELKA, Museum of Vertebrate Zoology, University of California, Berkeley, Calif. 94720. (1962)

The purpose of this project is to contribute to improvement of the teaching of ecological relationships in college courses in biological sciences by preparing a motion picture illustrating predator-prey relationships in biotic communities, as exemplified by certain bird and mammal populations in the Antarctic and Arctic. The basic footage of the film was previously obtained as a part of research carried out at the Poles by the director and his associate, Dr. William J. Maher (then of San Francisco State College; now at the University of Saskatchewan, Saskatoon, Saskatchewan, Canada).

The film, *Polar Ecology: Predators and Prey* (16mm, sound-color, 20 min.) may be obtained from University Extension, University of California, Berkeley.

110. Instrumentation Methods for Physiological Studies (Project IMPS). NORMAN N. GOLDSTEIN, JR., Physiology Department, University of California, Berkeley, Calif. 94720. (1961–1964)

The primary objectives of the project are: (1) to design a complement of instruments and accessories that adequately serve laboratory instruction in physiology, while at the same time representing a cost reduction of *five* to *ten* times over research equipment; and (2) to provide a literature to guide instrument construction, and to facilitate rational application of the instruments to the study of membrane potentials, nerve conduction, bioelectricity in plants, cardiac electrophysiology, muscle contraction, cardiovascular sound, peripheral vascular pressures and flow, and sensory activity.

The main instrument developed and now commercially avaliable is a high-gain (200 mμv/cm), slow-sweep, five-inch, long-persistence screen oscilloscope combined on the same chassis with a physiological stimulator that generates rectangular pulses of requisite and variable voltage, duration, and repetition rate. The oscilloscope-stimulator utility is extended by addition of simple nerve chambers, a plethysmographic transducer, cardiac microphone, pulse-pressure detector, electrodes, and several other accessories.

Work is now continuing through a grant from the Heath Company to expand the instrument set and applications and to develop a variety of recording methods. In progress is a textbook, teachers' guide, laboratory manual, and film series. The commercial version of the project hardware is available through the Heath Company. The main instrument called the IMPScope costs about $160 as kit and about $250 wired. A reprint of the report to the NSF containing background literature and student laboratory units can be obtained from the Heath Company. The McGraw-Hill Company will publish the text and laboratory manuals.

N. N. Goldstein, Jr., "Instrumentation and Teaching of Biology," *The American Biology Teacher* 25, 8 (1963).

Further information is available from the project director.

111. Models of Structural Relationships in Human Anatomy.

JOHN FRANKLIN HUBER, Department of Anatomy, School of Medicine, Temple University, Philadelphia, Pa. 19122. (1961–1963)

Plastic models were developed of various human structures which students have particular difficulty in visualizing. The models are suitable for use on monochrome closed-circuit television. Structures illustrated are the larynx (with special reference to functional mechanisms), the inguinal canal, the perineal region, and the general relationships of larger structures within the brain. The models readily and rapidly give an initial overall concept of structural relationships, serving as a basis or visual framework to which the details of the area can be added. Since basic understanding is often the most difficult goal to achieve, construction of the models requires a careful selection of the amount of pertinent detail basic to the visualization of the structure. Details are represented as accurately as possible.

The larynx model was used in the making of a motion picture entitled, *The Mechanisms of the Intrinsic Muscles of the Larynx.* The film, in both 16mm sound-color and 8mm cartridge, is available from the Audiovisual Facility of the U.S. Public Health Service, Communicable Disease Center, Atlanta, Ga. The model is planned for manufacture by Clay-Adams, Inc.

Further information can be obtained from the project director.

112. Inexpensive Electronic Equipment for Quantitative Physiological Studies.

(Secondary, College) CHARLES K. LEVY, Department of Biology, Boston University, Boston, Mass. 02215. (1961–1964)

Most modern equipment for teaching physiology in the laboratory is modified research equipment which is too expensive and too complicated for use by small schools For this reason, the project designed simple, rugged, and inexpensive physiological equipment made from standard electronic parts and specifically designed for school laboratory work. The equipment was prepared as: (1) do-it-yourself assembly kits, and (2) already assembled models. Built-in test jacks and ready access to electronic components permit simple repair and replacement of parts. Simplified but detailed wiring diagrams in layman's language accompany the equipment; an instructor's manual of suggested laboratory experiments for using the equipment will also be supplied. Four pieces of equipment are now under development: (1) an electronic stimulator which provides shock stimuli over a wide range of parameters, (2) a simple amplifier to magnify bioelectric responses, (3) an electronic paper driver recorder, and (4) a simple, cheap, rugged electric kymograph.

Further information can be obtained from the project director.

113. X-ray Circuit Model for Studying X-ray Circuit Parameters.

(Secondary, College) LLOYD M. BATES, Department of Radiological Sciences, School of Hygiene and Public Health, The Johns Hopkins University, Baltimore, Md. 21205. (1960–1961)

The model is a basic X-ray generator circuit, but the potential differences generated in the secondary part of the circuit are less than 300 v. The circuit will not generate X-rays, of course, but circuit component values are chosen so that circuit parameters are similar to those in an X-ray generating circuit. The model includes relay switching, autotransformer and rheostat voltage control, full-wave rectification, tube current and voltage meters, and primary and secondary circuit pilot lights. A light-producing tube is incorporated in the circuit. The intensity of the light emitted from this tube varies with the "X-ray" tube voltage and current in approximately the same manner as X-ray intensity would vary. The wiring display permits study of the circuit. Component contacts are exposed so that voltmeters and oscilloscopes can be connected at any desired points in the circuit. Jacks incorporated in the model make it possible to place current measuring instruments in the circuit without disconnecting leads.

A brochure which includes a complete description of the model, a wiring diagram, a parts list, a shop drawing for chassis construction, and a manual of experiments is available from the project director.

114. Sectionable Model of Human Brainstem for Individual Student Use. Dorothy N. Naiman, Department of Physiology and Health, Hunter College of the City University of New York, Bronx, N. Y. 10468. (1962-1964)

The difficulty many students have in visualizing the complex structures of the human brain led to the effort to develop realistic, accurate models which could be produced cheaply enough to enable each student to have his own to study, label, section, and color as he wished. The model finally produced can be sectioned and reassembled, studied in the laboratory or at home, and colored in accordance with a functional scheme.

It is cast of a semi-flexible urethane foam (NOPCO-FOAM F 506), which sets in about 30 seconds to the consistency of stale white bread. This light-weight resin has the advantages of a smooth surface on which both ballpoint writing and felt-marker coloring are feasible. It can be colored before polymerization, and bonds readily to a pre-cast inset (ventricular system). Acceptable casts can be made after very little practice at an approximate cost of 50 cents per cast (2.5 x natural size) for prepolymer and catalyst.

The model can be readily sectioned in any plane with an ordinary serrated kitchen blade. If sections are reassembled by threading cords through them, the anatomic features of the whole organ can be seen; the sections can be slid apart so that sectional landmarks can be correlated with gross structure. Although this particular model was designed for individual student use in neurology courses, it might serve as a useful demonstration in less advanced courses if pre-sectioned and appropriately colored. Furthermore, while this model is of the human brainstem, molds and models of other organs and other species could be made after a little experience and without elaborate equipment.

Effort is being made to interest a manufacturer in producing the model on a commercial basis.

"The Use of Disposable Brain Models," *American Biology Teacher* 26 (3), 178–181 (1964).

"A Student-Constructed Model for the Study of Neuroanatomy," *Journal of the Association of American Medical Colleges* 23, 303 (B. Konheim, joint author) (1948).

115. Working Model of Human Circulatory System. *(Elementary, Secondary, College)* Thomas I. Marx, Engineering Division, Midwest Research Institute, Kansas City, Mo. (Present address: Sigma Instruments, Incorporated, Braintree, Mass. 02185.) (1959–1960)

The circulatory model contains a heart, aorta, arterioles, capillary beds, veins, and pulmonary circuit. The heart consists of passive atrial chambers plus ventricles pumped by a motor-driven mechanism. All four heart valves are represented. The aorta is made of thin-walled rubber tubing which distends to accept the surge of liquid with each heartbeat. Other blood vessels are made of clear plastic tubing. Constrictor bars on the arterioles are used to regulate blood flow through plastic-foam capillary beds. The pulmonary circuit consists of a thin-walled pulmonary artery, a plastic-foam lung bed, and a pulmonary vein. Mercury manometers are used to indicate arterial and venous pressure, and an orifice-plate meter indicates blood flow rate. The two heart sounds can be heard through a stethoscope placed on the aorta. Experiments can be performed to show the effects of heart rate, stroke output, peripheral resistance, and blood volume on blood pressure and cardiac output. The type of flow (i.e., steady or pulsatile) can be observed at various points in the circulatory system.

A report describing the circulatory model, its construction and uses, is available from the Midwest Research Institute.

116. Monitoring Physiological Parameters in the Student Laboratory. Robert I. Macey and Lester Packer, Department of Physiology, University of California, Berkeley, Calif. 94720. (1962–1964)

Some devices have been fabricated for use in the student physiology laboratory to study quantitative relations between metabolism and specialized physiological functions. In particular, a polarographic apparatus for measurement of oxygen tension has been adapted for use in conjunction with a simple and inexpensive universal photometric device. The application of the O_2 electrode and the student photometer for the measurement of energy production, regulation, and utilization (transport and permeability) at the cellular level is illustrated by sample student exercises. Simple and economical block construction methods are employed to allow student assembly of components.

Further information can be obtained from the project directors.

117. Stereophotomicrography and Other Methods for Teaching and Demonstrating Submacroscopic Anatomy. T. Walley Williams, Department of Microanatomy, Medical Center, West Virginia University, Morgantown, W. Va. 26506, and Charles C. Boyer, Department of Anatomy, Indiana University Medical Center. (Grantee: West Virginia University.) (1959–1965)

Highly specialized technics have been developed for preparation of tissues and organs which are photographed in three dimensions to show structural relationships not observable by usual histological technics. The visualization of the peripheral vascular beds of tissues and organs in three dimensions are also included in the project. The stereo fields will eventually be available to institutions and individuals interested in using them for teaching and demonstration purposes.

For further information write to: T. W. Williams, "The Visualization of Vertebrate Capillary Beds by Intravascular Precipitation of Lead Chromate," *Anatomical Record* 100, 1 (1948).

A. C. Higginbotham, F. H. Higginbotham and T. W. Williams, "The Vascularization of Blood Vessel Walls," *Evolution of the Atherosclerotic Plaque*, University of Chicago Press (1964).

C. C. Boyer, T. W. Williams, and F. H. Stevens, "The Blood Supply of the Temperomandibular Joint," *Journal of Dental Research* 43, 2 (1964).

T. W. Williams and C. C. Boyer, "A Procedure for the Selective Differentiation of Epithelial Derivatives in Gross Blocks of Embryonic and Adult Tissues," *Journal of Dental Research* 43, 2 (1965).

Further information may be obtained from the project director.

118. Teaching Aids for Integrated Embryology-Comparative Anatomy Courses. *(Secondary, College)* LOUIS E. DELANNEY, Department of Zoology, Wabash College, Crawfordsville, Ind. 47933. (1959–1963)

Pig embryo: Differentially colored, three-dimensional, plastic model. The transparent plastic model will help students to identify positions of single sections in the whole embryo.

Dissectable models of skulls. Skulls of a primitive amphibian, a selected reptile, and a selected mammal will be sculptured so that they can be separated into individual bone components and can be reassembled to test knowledge of individual components of a specific skull. Substitutions from one type of skull to another can be made to simulate evolutionary changes.

Further information can be obtained from the project director.

119. Manikin for Teaching Endotracheal Intubation. DONALD W. BENSON, Johns Hopkins Medical Institutions, Baltimore, Md. 21218. (1962–1963)

A manikin was developed in which the head and neck model of the human body is anatomically correct and suitable for the teaching and practice of endotracheal intubation. A metal skeleton-like superstructure which imitates the normal maneuverability of the cervical spine and the atlanto-occipital joint was designed. New plastic techniques will make possible the simulation of the texture, strength, and maneuverability for all the tissues of the oropharyngeal cavity and the larynx.

Further information can be obtained from the project director.

120. Student Laboratory Equipment in Visual Science. *(College, Graduate, and Medical School)* THORNE SHIPLEY, Department of Ophthalmology, School of Medicine, University of Miami, Coral Gables, Fla. 33124. (1962–1965)

Several student laboratory instruments for use in various college courses in visual science were developed. These allowed student testing of visual acuity, dark-adaptation, color perception, binocular vision, and certain associated basic visual functions, with simple and inexpensive apparatus not previously available. The project entailed the construction of one working model of each instrument. The instruments are intended for use in such courses as a one-year graduate laboratory course in visual science, undergraduate psychology, first-year medical school physiology, and resident training in ophthalmology.

121. Students' Warburg and Other Respirometric Apparatus. *(Secondary, College)* THOMAS I. MARX, Engineering Division, Midwest Research Institute, Kansas City, Mo. (Present address: Sigma Instruments, Incorporated, Braintree, Mass. 02185.) (1961–1962)

Apparatus of different degrees of refinement has been developed. The simplest, a Fenn volumeter, consists of two small flasks connected by a horizontal capillary tube carrying a drop of liquid. When the respiration of a simple biological system placed in one of the flasks causes the pressure in the flask to change, the liquid drop moves so as to equalize the pressure in both flasks, giving a measure of the biological gas exchange. Oxygen and carbon dioxide rates are separated by chemically absorbing the latter gas in a duplicate experiment. The second type of respirometer, a Warburg apparatus, consists of a reaction flask connected to a vertical U-tube manometer which contains a reservoir of manometer fluid in a rubber bulb. The bulb can be compressed to bring the liquid in the closed arm to a reference point. The open arm of the manometer can be connected to a temperature and pressure control flask.

A report on the apparatus is available from Midwest Research Institute.

122. Student Ophthalmoscope. *(Secondary, College)* THOMAS I. MARX, Engineering Division, Midwest Research Institute, Kansas City, Mo. (Present address: Sigma Instruments Incorporated, Braintree, Mass. 02185. (1959–1960)

A very simple but striking experiment within the scope of college and high school biology courses is ophthalmoscopic examination of the human eye. The instrument permits observation of active blood vessels and nerves in the intact, unanesthetized eye. The ophthalmoscope illuminates the fundus of the eye so that the observer can see structures of the fundus while avoiding reflections from the cornea. The instrument can also be used in physics classes for demonstrations in geometrical and physiological optics.

The project report describes a number of experiments which encourage students to become proficient in using the instrument and provides an introduction to the physiology of the eye. The instrument will be marketed by the Central Scientific Company.

Thomas I. Marx, "The Construction and Use of a Simple Ophthalmoscope," *The American Biology Teacher* 23, 71 (1961). A report is available from Midwest Research Institute.

E. Chemistry

For additional projects related to this section see also:

38. Laboratory Experiments for Chemistry Courses.
39. Visual Aids for Teaching Chemistry.
73. Introductory Course in Chemistry and Physics.
79. Overhead Projection Series of Lecture Experiments in the Sciences.
163. Objectives for Chemical Engineering.
168. Application of Stochastic Processes to Reaction Kinetics.
278. Sience Teaching Center: College Science.
308. Microwave Spectroscopy Experiment.
310. Versatile Nuclear Coincidence Apparatus for Undergraduate Use.

123. Advisory Council on College Chemistry (ACCC). L. CARROLL KING (Chairman), Department of Chemistry, Northwestern University; WILLIAM B. COOK (Executive Secretary), Department of Chemistry, Stanford University, Stanford, Calif. 94305. (Grantees: University of Pennsylvania, 1962–1965; Stanford University, 1965– .)

The Advisory Council on College Chemistry is an independent group of thirty chemists whose objective is to provide the leadership and stimulus for a number of projects, throughout the chemical education community, which will result in imaginative up-to-date curricula, more effective tools for learning, improved textual materials, innovations in the experimental aspects of chemistry instruction, and stimulation of interdisciplinary programs for nonscience majors, including prospective elementary school teachers.

Seven standing committees of the Council constitute action panels dealing with introductory chemistry, curricula and advanced courses, teaching aids, teacher development, resource papers, science for nonscientists, and newsletters. In progress or being planned is work on stimulating production of interdisciplinary teaching materials, chemistry in two-year colleges, alternatives to conventional introductory chemistry laboratory, content of introductory college chemistry courses and training of teaching assistants.

A continuing series of Resource Letters published in the *Journal of Chemical Education* provides college chemistry teachers with sources of information on concepts and developments useful in the teaching of the introductory course. Written by authorities in the field, these articles should be valuable to all chemists not expert in the particular topic covered. Published to date or in preparation are papers on Ligand Field Theory, Elementary Chemical Thermodynamics, Bond Energies, Isoelectric Principles, Atomic Orbitals, Catalysis, Atomic Weights, Energy Absorption at the Molecular Level, Entropy, and Flames and Combustion.

An annotated list of chemistry texts, references, and journals are in preparation for the guidance of small departments which are attempting to acquire adequate chemistry libraries.

A series of novel experiments for introductory chemistry laboratory will be published in the *Journal of Chemical Education.* A collection of thermochemical experiments appeared in the January 1965 issue, and a general series appeared in the September 1965 issue.

A volume of reprints of selected experiments which have appeared in the *Journal of Chemical Education* during the past several years will be published after the experiments have been evaluated, tested and revised.

In cooperation with the other disciplines, the Advisory Council on College Chemistry is sponsoring efforts to develop more effective physical science courses for nonscience majors and to develop resource books to improve the material in introductory chemistry.

Reprints of three reports, "The Logistics of General Chemistry Teaching in Large Sections," October 1963; "Curriculum Experimentation," October 1963; and "The Scope, Depth and Impact of Non-traditional Topics in General Chemistry," February 1964, are available. Requests for reprints, the Newsletter, or other publications should be addressed to the executive secretary of the Council.

124. Modern Undergraduate Analytical Chemistry Courses.

H. A. LAITINEN, Department of Chemistry and Chemical Engineering, University of Illinois, Urbana, Ill. 61803. (1961–1965)

This project involves development of two new analytical chemistry courses, particularly the design of new laboratory experiments. The first course stresses the role of analytical chemistry, both chemical and instrumental, in research. About half the laboratory time (one long afternoon per week) is devoted to learning the fundamentals of chemical and instrumental methods. The other half is devoted to a study of chemical problems by analytical methods.

Examples of the types of problems being investigated for development into student experiments are: (1) a study of salt effects using buffer solutions, indicators, and pH meter; (2) study of coprecipitation of alkali metals with magnesium by flame photometric analysis of $MgNH4PO4$; (3) gas chromatographic separation of *cis* and *trans* olefins followed by determination of rate of isomerization of each, again using gas chromatography; (4) evaluation of an ion-exchange column, prediction, and verification of degree of separation of metal ions; (5) assignment of sources of error by statistical inference and analysis of variance.

It is expected that successful experiments will be described by publications in such suitable media as the *Journal of Chemical Education.*

125. Course in Elementary Organic Chemistry.

ALSOPH H. CORWIN, The Johns Hopkins University, Baltimore, Md. 21218. (1963–1964)

The prime objective of the course is to provide a background in organic chemistry for chemists, chemical engineers, premedical students, and other science majors that will enable them to undertake an intelligent study of the current journal literature in the field. The course emphasizes the methods of scientific logic and independent thinking in contrast to memorization. The intellectual problems met in scientific reasearch are stressed.

The method is to give students a thorough grounding in the principles of organic structural determinations in the first section of the course. Having secured this necessary background with a concurrent understanding of the empirical nature of the science, students return to first principles of chemical bonding, making and breaking of bonds, and the bases for simple mechanistic determinations. The course utilizes a variety of visual aids, including many lecture demonstrations.

The project report and course description may be obtained from the project director.

126. Experimental Laboratory Course in Organic Chemistry.

MELVIN S. NEWMAN and WILLIAM WHITE, Department of Chemistry, Ohio State University, Columbus, Ohio 43210. (1960–1961)

The main objective of this course, a first organic laboratory course, is to help prepare chemistry majors for research. Students are supplied with a variety of glassware designed for research, electric stirrers, magnetic stirrers, hot plates, heating mantles with temperature controls, vacuum pumps, etc., at an estimated cost of $200-$300 per student. Students are sent to the library to look up ways in which certain reactions had been done and are to make their own decisions as to what to do. Features stressed included: (1) repetition and refinement of experiments, (2) comparison of efficiency of alternative syntheses, (3) techniques in multistep synthesis, and (4) report writing.

M. S. Newman and P. G. Gassman, "An Experimental Laboratory Course," *Journal of Chemical Education* 40, 203 (1963).

A final report is available from the project directors.

126A. Experiments for College Chemistry.

J. ARTHUR CAMPBELL, Department of Chemistry, Harvey Mudd College, Claremont, Calif. 91716. (1966–1969)

Lecture experiments and a laboratory course for the initial three semesters of an undergradute chemistry curriculum are being developed. The laboratory experiments are being designed so that the student is led to interpret experimental results in terms of thermodynamics, kinetics, quantum theory, structure, and electrical interactions. The experiments are being correlated conceptually and temporally with lecture material so that they can serve as the basis of class discussion in which student data and conclusions are compared in as realistic a research fashion as possible with one another and with the accepted interpretation. Students will be given a minimum of direction and allowed to choose or design their own experimental approaches within a defined area of inquiry.

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A series of lecture experiments is being developed which complements the thermodynamic and physical chemical approach of the introductory course. The project is also experimenting with the use of films as a means of demonstrating phenomena which are not adequately comprehended from lecture and laboratory experiments.

Further information will be available from the project director.

127. Experiments in Covalent Chemistry. J. H. Richards, Division of Chemistry and Chemical Engineering, California Institute of Technology, Pasadena, Calif. 91109. (1965–1956)

The project is developing a new laboratory course for the sophomore year of the chemistry curriculum. The lecture course is being broadened to include the nature and chemistry of inorganic covalent compounds, and the laboratory work will be synchronized as closely as possible with the lecture course. Experimental methods for elucidating structure and determining reaction mechanisms will be stressed, including the techniques of infrared and nuclear magnetic spectroscopy. The first quarter of the laboratory course will concentrate on structural elucidation of unknown substances, preparation of derivatives, and the separation and analysis of mixtures by various techniques including fractional distillation, thin-layer and vapor-phase chromatography, and spectroscopy. General synthetic preparations and determination of reaction mechanisms will occupy the second and third quarter. In general, the synthesis of a substance will be the first step to further studies of a structural or dynamic nature. For maximum utilization of equipment, there will be available a selection of experimental approaches from which the student can choose.

Some specific experimental possibilities are: solvolysis of benzyl tosylates; valence tautomerism; solvolysis of metallocene derivatives; intrinsic molecular asymmetry; keto-enol equilibrium; hindered internal rotation in amides; cyanohydrin formation; kinetics of ring inversion of cyclohexane; photochemistry; carbene chemistry; synthesis and properties of nonclassical aromatic systems; resolution by asymmetric induction and enzymatic methods; chemistry of coordination compounds.

Further information is available from the project director.

128. Films for College Chemistry. *(Secondary, College)* Andrew Patterson, Jr., Department of Chemistry, and David G. Anderson, Department of Educational Motion Pictures, Yale University, New Haven, Conn. 06520. (1960–1969)

Most of these films present demonstration experiments, but some show laboratory techniques, explain abstract ideas through animated drawings, or serve as introductions to basic research. Representative titles are: *Solubility Product, Le Chatelier's Principle, Metals & Non-Metals, Single-Pan Analytical Balance, Proton Motions in Ice, Quantitative Transfer, Patterns of Scientific Investigation, Operating Principles of Vacuum Pumps.* The demonstration films are usually quite short and rely heavily on the visual image to make their point. Although sound tracks are provided, most of the films are made in such a way that the teacher can readily turn off the sound and interpret the visual material according to his own views. As an aid in doing this, graphic summaries, called preview sheets, are provided with each demonstration film.

In addition to the short, single-concept films, a few films of conventional length have been produced. This more comprehensive format, however, is usually confined to topics that are either very easy to teach, or very difficult; for example, such routine laboratory information as *Laboratory Burners* or, at the other extreme, such complex material as *Solution of Alkali Metal in Liquid Ammonia.*

Approximately 20 of the films will be made available in 8mm cartridges, without sound tracks, for automatic projection. A complete list of films and information about sale and rental may be obtained from Association Films, Inc.

129. Equipment and Experiments for Teaching Instrumental Analysis. *(Secondary, College)* Frederick D. Tabbutt, Department of Chemistry, Reed College, Portland, Ore. 97202. (1960–1963)

The primary purpose of this project is to develop inexpensive, simple equipment to be assembled by students as a means for teaching experimental instrumentation. The main features of the equipment are: Poggendorf apparatus (includes Weston cell and calomel electrode); magnetic stirrer; pH meter; polarograph; servomechanism for use as recording potentiometer; recording polarograph; amperostat; potentiostat; automatic titrator (records titration curve and can shut off automatically); Ebert monochromator; spectroscope; spectrograph; emission spectrophotometer; absorption spectrophotometer, and recording single beam spectrophotometer.

Details of the experiments and equipment, including specifications, price of parts, and construction time by hour, may be found in: F. D. Tabbutt, *Journal* *of Chemical Education* 39, 611 (1962), and R. H. Schoenbeck and F. D. Tabbutt, *Journal of Chemical Education* 40, 452 (1963).

130. Supplementary Teaching Aids for Introductory Chemistry. DONALD H. ANDREWS, Department of Chemistry, The Johns Hopkins University, Baltimore, Md. 21218. (Present address: Florida Atlantic University, Boca Raton, Fla. 33432.) (1958–1960)

Experiments were developed to accompany a modern course in chemistry based essentially on thermodynamics and elementary quantum mechanics. New ones include the construction of a cloud chamber for the study of radioactivity, measurements with a vacuum line to determine gas behavior, vapor pressures, molecular weights, rates of reaction, and the effect of catalysts. A simple ice calorimeter was devised for the measurement of heats of reaction, fusion, and solution.

Several motion picture films, showing moving models of atomic and molecular structure, chemical reactions illustrated by model motions, and related topics were made. A film summarizing the wave interpretation of matter at an elementary level has been prepared and is available on a rental or purchase basis (see below). In addition, several new teaching approaches to thermodynamics and quantum mechanics for beginning students have been worked out and will be presented in forthcoming publications.

R. J. Kokes, M. K. Dorfman, and D. H. Andrews, "General Chemistry at the Johns Hopkins University," *Journal of Chemical Education* 39, 16 (1962).

R. J. Kokes, M. K. Dorfman, and T. Mathia, "Experiments for General Chemistry. I: Cloud Chamber Molecular Film and Atomic Weight of Silver. II: A Simple Vacuum System. III: Calorimetry. IV: Chemical Equilibrium: The Hydrogenation of Benzene. V: Equilibria in Ionic Solutions," *Journal of Chemical Education* 39, 18, 20, 90, 93 (1962).

Ancillary publications:

D. H. Andrews and R. J. Kokes, *Fundamental Chemistry* (2nd ed.), John Wiley and Sons, Inc. (1965).

D. H. Andrews and R. J. Kokes, *Instructor's Manual for Fundamental Chemistry,* John Wiley and Sons, Inc. (1962).

D. H. Andrews and R. J. Kokes, *Laboratory Manual for Fundamental Chemistry,* John Wiley and Sons, Inc. (1962).

D. H. Andrews and W. Millis, *Unheard Melodies* (16mm, sound-color film), Foundation for Integrative Education (1960), distributed by Radiant Films, Inc.

131. Electronic Instrumentation for Quantitative Chemistry. CHARLES N. REILLEY, Department of Chemistry, University of North Carolina, Chapel Hill, N. C. 27514. (1961–1962)

Equipment and apparatus, which illustrate the more advanced aspects of electronic instrumentation for quantitative chemistry, and suitable panel layouts and experimental procedures have been developed:

1. *Analysis of Passive Networks.* A panel layout demonstrates the properties of resistors, capacitors, and inductors in resonant circuits, filters and phase-shifting networks. Transient and steady-state currents are studied. The Laplace-transform method is emphasized as a useful tool in circuit analysis.

2. *Operational Amplifiers.* These amplifiers are used to illustrate the basic principles of feedback as applied to analog computation. An instrument demonstrates the use of these amplifiers in performing the operations of addition, subtraction, integration, and differentiation in various combinations. The use of operational amplifiers for control purposes (i.e., through establishing an identity) is shown.

3. *Analog Computer.* A small computer using operational amplifiers solves the differential equation of damped, simple harmonic motion, the equation of first-order chemical kinetics, and linear simultaneous equations in two variables.

4. *Feedback Amplifiers.* A two-stage amplifier on a panel layout illustrates in detail the principles of regenerative and degenerative feedback.

5. *Servomechanism.* A panel layout illustrates the important principles of servomechanisms. It can also be used as a recorder.

6. *Semiconductor Components and Non-Linear Circuitry.* A panel layout demonstrates the characteristics and applications of transistors, diodes, and photocells. It includes a transistorized phase-shift oscillator, and diode modulating, clipping, limiting, and clamping circuits.

7. *Multivibrators.* The principles of monostable, bistable, and astable multivibrators and the Schmitt trigger are illustrated by a panel layout. Transistorized circuitry is used.

8. *Special Purpose Tubes.* Panel layouts illustrate the principles and applications of neon bulbs, voltage regulators, thyratrons, and electron-ray tubes. A panel demonstrates the glow-tube counter and its use in a two-stage decade counter.

C. N. Reilley and D. T. Sawyer, *Experiments for*

Instructional Methods, Part V, McGraw-Hill Book Company, Inc. (1961).

Further information can be obtained from the project director.

132. Integrated Set of Analytical Instrument Building Blocks. *(Secondary, College)* EDWARD N. WISE, Department of Chemistry, University of Arizona, Tucson, Ariz. 85721. (1959–1963)

An integrated set of instrument building blocks is being designed to permit a student to study a single instrumental principle in detail and then to make and study a complex instrument by interconnecting the building blocks (or modules). The modules are being designed with the following goals in mind: (1) simplicity of construction, (2) accessibility of all parts, (3) complete interchangeability of units having similar functions, (4) low cost, and (5) ruggedness to withstand student handling, inspection, and operation. Each unit will be sufficiently simple to permit construction by a department with a limited budget. The list of modules tentatively includes: photovoltaic cell housing, microammeter, light source, light source supply transformer, beam splitter, test tube holder, beaker holder, prism monochromator, grating monochromator, intereference filter-wedge monochromator, vacuum phototube housing, gas phototube housing, resistance photocell housing, high impedance amplifier, current amplifier, regulated power supply, variable power supply, photomultiplier housing, photomultiplier power supply, aspirator burner, magnetic stirrer, ultraviolet source, ultraviolet power supply, millivolt selector and terminating relay, first and second derivative amplifier and terminating relay, solenoid burette pinch clamp, constant current regulator, mechanical counter with motor drive, syringe micrometer burette, servo-amplifier, X-Y recorder, plus seven modules of more specialized character.

Most of the modules have been designed and prototypes are being tested by students. Construction information, including reduced scale drawings, has been published in the *Journal of Chemical Education* 40, 73 (1963).

133. Apparatus for Chemical Analysis and Preparation on the Micro and Semi-Micro Scale. *(Secondary, College)* JOHN T. STOCK, Department of Chemistry, University of Connecticut, Storrs, Conn. 06268. (1960–1965)

1. Equipment for qualitative analyses on the small scale.
2. A simple micro apparatus for extraction-evaporation analysis.
3. A titration controller for demonstrating the behavior of acid-base indicators.
4. The safe use of toxic volatile reagents in introductory experiments.
5. A compact set of semi-micro apparatus for general chemical operations.
6. A simple device for indicating pH change during acid-base titrimetry.
7. A simplified apparatus for nitrogen determination by the Kjeldahl method.
8. Techniques for the drop-scale separation of ions on impregnated filter-paper strips.

Information concerning the work has been published in various recent papers in the *Journal of Chemical Education, School Science Review* and *The Science Teacher.*

J. T. Stock and P. Heath, *Small Scale Inorganic Qualitative Analysis,* University Tutorial Press, London, 5th ed., 1963.

J. T. Stock, M. A. Fill, and E. A. Robinson, *Introduction to Organic Chemistry,* University Tutorial Press, London, 2nd ed., in press.

134. Multipurpose Analytical Chemical Instrument Employing Operational Amplifiers. CARL M. STEVENS, Department of Chemistry, Washington State University, Pullman, Wash. 99163. (Former director, Charles F. Morrison, Jr.) (1961–1963)

A very widely adaptable manifold for operational amplifiers is mounted near an auxiliary panel containing the most commonly needed hardware items (switches, relays, bias packs, meters, etc.). These units are rack-mounted with power supplies and a strip-chart recorder. By the use of patch cords and plug-in resistors, capacitors, diodes, etc., the device can be programed to serve the electronic functions of many instruments. Thus far, over thirty practical instruments have been synthesized. These include IR-compensated polarographs, coulometers, conductance devices linear in conductance, chronopotentiometer, digital integrator for a gas chromatograph, potentiometric autotitrators, etc. Complex units are made up on plug-in boards so that they need not be disassembled to free the console. Several applications can be used at the same time.

Facilities needed for construction are those of routine electronic repair or construction. A drill press and light sheet metal tools are desirable. Approximate cost of construction, including a good selection of amplifiers and a commercial power supply, is $2,000. This includes labor but not the strip-chart recorder. The availability of a sensitive oscilloscope makes possible a number of additional applications and aids in the testing of new circuits.

Copies of a complete report giving construction details, theory of operation, and typical applications have been distributed free of charge to all four-year U. S. colleges and universities. A limited number of additional copies are available from Dr. Morrison, 4790 Sioux Drive, Boulder, Colo. 80302.

135. Components for Student-Built Instruments for Instrumental Analysis.

GALEN W. EWING, Department of Chemistry, New Mexico Highlands University, Las Vegas, N. Mex. 87701. (Present address: Department of Chemistry, Seton Hall University, South Orange, N. J. 07079.) (1960–1964)

Modular apparatus has been designed primarily as teaching tools for college courses in instrumental chemical analysis. Each module, in general, fills a specific function required in the synthesis of analytical instruments. Several modules, as selected by the student, are to be interconnected with patch cords to form a functioning instrument, such as a pH meter, a coulometric titrator, or a visible spectrophotometer. Many of the modules can be utilized in each of several instruments.

The electrical modules are: calibrated potential source, calibrated source of constant currents, variable-range meter, operational amplifier, electrometer, AC Wheatstone bridge with phase-sensitive detector, and potentiostat. An absorptionmeter constitutes another module; it includes interchangeable Littrow (glass) prism and reflection grating, also provision for operation as a filter photometer. In addition, a constant-delivery solution pump and a miniature recorder (commercial units) are recommended for titration purposes.

The apparatus has been described in the *Journal of Chemical Education* 42, 32–34 (1965). A laboratory manual has been written to accompany the equipment. Manufacturing has been undertaken by A. R. F. Products, Inc. The manual is distributed temporarily by the manufacturer, but will be published by Plenum Press. Further information about the instruments may be obtained from the manufacturer.

136. Quantitative Molecular Models Representing the Molecular Charge Distribution.

KARL H. ILLINGER, Department of Chemistry, Tufts University, Medford, Mass. 02155. (1961–1965)

Detailed calculations have been carried out on the electronic charge densities of: (a) prototype orbitals, (b) atoms, and (c) simple molecules. The results of these calculations are representable in terms of quantitative contour maps of the electronic charge density relevant to the given system. Integration of the electronic charge density over surfaces of constant charge density has been carried out in most cases. In the case of atoms, the effects of hybridized wave functions and the result of spin correlation in polyelectronic atoms have been examined. An extensive study has been made of the molecular charge densities predicted from a series of wave functions for hydrogen molecule ion and hydrogen molecule; molecular quadrupole moments have been calculated from the charge densities in these cases.

This study is directed to students at various levels in the curriculum in chemistry and physics. The results on the prototype orbitals, translated into a three-dimensional, quantitative model of the charge density, are relevant to introductory courses, as are some of the results on atoms. The examination of spin correlation in polyelectronic atoms, and the results on molecules are directed to courses in physical chemistry and introductory wave mechanics and valence theory.

Further information is available from the project director.

137. Models of Crystallographic Space Groups.

ALBERT J. FRANK, Department of Geology, and HAROLD ZABSKY, Department of Chemistry, St. Louis University, St. Louis, Mo. 63103. (Lyman J. Wood, former project director, deceased.) (1961–1964)

This material consists of: (1) eighty-five stereoslides in color prepared by photographing symmetry models of a number of the space groups, which have been and are being constructed in the authors' laboratory; (2) a 100-page descriptive monograph to be used while viewing the slides. The symmetry models are of two sorts: models constructed of cork balls, and models made of cardboard. The centers of cork balls of different colors have coordinates which are derived by means of crystallographically significant symmetry operations. The orientations of the cork balls are fixed by colored pegs inserted in such a way that a ball and inserted pegs can be treated (in most cases) as an unsymmetrical unit. Many of the cardboard models have been prepared from descriptions of Fedorov's stereohedra; some of these will aid in understanding the Bravais translations.

Arrangements have been made to supply the stereoslides at cost to interested scholars.

Further information can be obtained from Dr. Frank.

138. Three-Dimensional Models in Phase Rule Studies.

(Secondary, College and *Graduate School)* Ralph H. Petrucci, Western Reserve University, Cleveland, Ohio 44106. (Present address: Department of Chemistry, California State College at San Bernardino, San Bernardino, Calif. 92407.) (1962–1964)

Prototype models which have been prepared from plaster of Paris include:

1. P/V/T model for water, including all of the high-pressure modifications of ice. (The model is dissectable at several constant temperatures.)
2. Complete three-dimensional model, in seven parts, for a binary system exhibiting eutectic formation in the solid-solid-liquid equilibrium and azeotropism in the liquid-vapor equilibrium.
3. A simple ternary eutectic system. (This model consists of isothermal sections and the several state spaces.)
4. A ternary eutectic system with one binary compound. (This model consists of several isothermal and one polythermal section.)

It is proposed to make the results of this project available in one or both of two forms: stereophotographs of the several models, together with a comprehensive descriptive booklet; or lightweight, nonbreakable copies of the models themselves. Because the type of commercial production which is undertaken will depend on the market potential, readers are urged to communicate to the project director any interest in the possibilities mentioned.

A description of the methods of construction and the use of these models appears in an article by R. H. Petrucci, *Journal of Chemical Education* 42, 323 (1965). Further information can also be obtained from the project director.

139. New Atomic, Molecular, and Crystal Models.

(Secondary, College) R. T. Sanderson, Department of Chemistry, Arizona State University, Tempe, Ariz. 85281. (1959–1964)

The new atomic and molecular models developed in this project, although designed primarily to aid in lectures, can also be used in a wide variety of laboratory exercises. The molecules and crystals are easily assembled, using wood or pipe cleaner connectors and glue. The atomic models and at least some of the molecular models are equipped with small balls attached to the atomic surface to represent outer-shell electrons and vacancies, and are placed appropriately to indicate the directional nature of the orbitals.

R. T. Sanderson, *Teaching Chemistry with Models,* D. Van Nostrand Company. This book suggests in detail many ways in which these models may be used in the teaching of chemistry, both as lecture aids and in student exercises. Three 45-minute sound-color lecture demonstrations on film describing the models and their construction and teaching uses are available for rent or purchase from Extension Division, State University of Iowa, Iowa City, Iowa 52240. Also see articles by R. T. Sanderson, *Journal of Chemical Education,* from 1951 to present. Reprints of some of these are still available, without charge, from the author.

140. Low-Cost Tetrahedral Models.

(Secondary, College) Louis F. Fieser, Department of Chemistry, Harvard University, Cambridge, Mass. 02138. (1961–1965)

Inexpensive plastic tetrahedral models for use in teaching concepts of structural isomerism, optical and geometrical isomerism, conformational analysis of cyclohexane and of polycyclic systems, spatial requirements for the formation of urea inclusion complexes, and structure of the ice crystal are available from the Rinco Instrument Company, who also distributes a book for use in high schools entitled, *Chemistry in Three Dimensions.* The following models are available: carbon, oxygen, nitrogen, carbon-carbon double bond.

141. Multipurpose Instrument for Quantitative Chemical Measurement.

Donald D. DeFord, Department of Chemistry, Northwestern University, Evanston, Ill. 60201. (1961–1964)

The instrument is being designed primarily for electroanalytical chemistry and titrimetry but will be useful for a wide variety of other types of measurement and control. The final apparatus will be basically an analog computer, with the measurement and control components incorporated in the computer loop, and may be programed in much the same manner as one programs a computer. When completed, the instrument can be used for voltammetry and related techniques, titrimetry, electroanalysis, coulometric analysis, and as a general-purpose recorder. The cost of the instrument is estimated at $4,000 to $5,000.

Further information can be obtained from the project director.

142. Nuclear Magnetic Resonance Spectrometer.

W. C. Gardiner, Jr., Department of Chemistry, University of Texas, Austin, Tex. 78712. (1962–1964)

An instrument for demonstration of NMR to undergraduate classes or for use in undergraduate laboratory experiments, has been developed. The circuits are inexpensive and simple to construct, and have proved to be capable of withstanding substantial abuse. The resonance signal is displayed on an ordinary oscilloscope. Proton and fluorine signals may be observed, and the effects of paramagnetic ions studied. Experiments for the physical chemistry laboratory have been prepared.

Further information can be obtained from the project director.

143. Pressure-Jump Apparatus for Measuring Rates of Rapid Reactions in Solution.

EDWARD M. EYRING, Department of Chemistry, University of Utah, Salt Lake City, Utah 84112. (1962–1963)

Several research techniques broadly classified as "relaxation methods" have been developed recently for measuring specific rates as large as 10^{11} M^{-1} sec^{-1} for chemical reactions in aqueous solution. In particular, the pressure-jump apparatus devised by Strehlow and co-workers is useful for measuring relaxation times of pressure dependent, ionic equilibria in the range 1 to 10^{-4} sec. The design for such an apparatus has been simplified, where possible, for use in a physical chemistry laboratory at the junior level. The completed apparatus, not including the necessary single-sweep oscilloscope, approaches a thousand dollars in cost. The experiment is valuable both as an exercise in chemical kinetics and as an introduction to Wheatstone-bridge circuitry.

A report is available from the project director.

144. Equipment for Demonstrating Magnetic Susceptibility and Absorption Emission Spectra.

EUGENE G. ROCHOW, Department of Chemistry, Harvard University, Cambridge, Mass. 02138. (1962–1963)

A projecting spectroscope for both absorption and emission spectra and a Gouy balance with a projecting scale for measurement of magnetic susceptibility have been produced for use in large lecture classes of 300-400 students.

Further information can be obtained from the project director.

F. Engineering

Multidisciplinary Engineering

For additional projects related to this section see also:

182A. A Computer-Oriented Systems Course.

185. Engineering Educational Development Program.

253. Experimental Curriculum in Engineering Mathematics.

254. Experimental Undergraduate Instruction in Computing.

259. Experimental Program in Engineering Mathematics.

262. Computer Science Course and Curriculum Development.

272. Teaching Aid for Analog Computer Instruction.

145. Commission on Engineering Education (CEE).

JOHN R. WHINNERY (Chairman), Department of Electrical Engineering, University of California, Berkeley, Calif. 94720; NEWMAN A. HALL (Executive Director), Commission on Engineering Education, 1501 New Hampshire Avenue, N.W., Washington, D.C. 20036. (Grantees: Educational Services Incorporated, 1962–1963; Commission on Engineering Education, 1964– .)

The Commission on Engineering Education was established to provide an objective, imaginative approach to improving engineering education. Its program encompasses the development of institutions, faculty, and educational resources. The Board of Directors represents many different engineering disciplines to insure a non-disciplinary approach and an emphasis on coordination. Advisory committees chart the potential development of ideas identified or accepted by the Board as having the greatest potential value in the devolpment of institutions, faculty, or resources.

In its mission the Commission serves first as a stimulus, actively encouraging the conception and development of ideas by its own members, by other institutions, or by industry. These may result in programs independent of the Commission but still may remain activities in which the Commission is catalyst and coordinator. In a few instances the Commission develops pilot operations which, when well underway, may be relinquished for continuation under other appropriate auspices.

Present programs include:

Central Office Operations, Newman A. Hall, Executive Director, Commission on Engineering Education, 1501 New Hampshire Avenue, N.W., Washington, D. C., 20036.

Design Laboratory Workshops, R. W. Mann, Engineering Project Laboratory, Massachusetts Institute of Technology, Cambridge, Mass. 02139. The Commission coordinated a series of Design Laboratory Workshops held concurrently at Case, Carnegie, Massachusetts Institute of Technology, University of California at Los Angeles and University of California at Berkeley, from June 14 to July 9, 1965, to develop and prepare more faculty to cope with realistic engineering design education situations. The workshops on the five campuses involved visiting faculty and their students, together with the sponsoring university faculty and their students, in design and laboratory projects which exploited the special characteristics and resources of the individual sponsor schools. Each school received a separate NSF grant for its own program. To exchange and reinforce the different experiences of participants at each workshop, visiting faculty and sponsoring faculty met to prepare documentation suitable for distribution to other engineering schools. A report on the Design Laboratory Workshop program, including a separate program carried out at Dartmouth, is available from Dr. Mann.

Engineering Concepts Curriculum Project (see Item 65.).

Bi-University Institutional Liaison for Development (BUILD). A grant from the Charles F. Kettering Foundation has enabled the Commission to embark on a cooperative program to develop a number of major centers of excellence in engineering education. The BUILD program involves the association of two institutions, one which might be called the "established" institution, and the other the "emerging" institution. This prototype operation has been under way between the University of Illinois and the University of Colorado since summer 1964. Faculty members of the two institutions have been brought together by the Commission to work out many different procedures to make the program effective, including: (1) visiting exchange professorships, (2) faculty leaves of absence for advanced study, (3) joint and cooperative research programs, (4) graduate student exchanges, (5) joint conferences and seminars, and (6) short-term exchanges.

Listen to Leaders in Engineering. A Sloan Foundation grant enabled the Commission to distribute, at no charge, the book *Listen to Leaders in Engineering* (A. Love and J. Saxon Childers, eds.) to a limited number of teachers of the Physical Science Study Committee and to members of the National Science Supervisors Association during spring 1965. The book is comprised of original pieces by some of the most outstanding men in engineering, many of whom were suggested to the editors by the Commission, and portrays the facts and progress of engineering through their eyes.

Future programs will involve:

1. *Use of Computers and Mathematical Techniques in Engineering Design.* A nine-week program for developing educational materials and providing experience for engineering faculty members in the use of computers in engineering design was held at the University of Michigan in the summer of 1965 under a direct grant from the National Science Foundation. This program was the outcome of exploratory discussions of the Commission's committee on the use of computers and mathematical techniques in engineering design. An advisory committee, provided by the Commission, selected the participants and is coordinating this program with other closely related activities of its computer commitee.

The Commission sponsored a conference on the impact of computers on education in engineering design in April 1966, and is developing an additional program for the collection of source material on the use of computers and mathematical techniques in engineering design.

2. *Computer Information System Sciences.* An advisory committee of the Commission has been organized; it will concern itself with the problem of how the digital computer can be used effectively in the electrical engineering undergraduate curriculum. This committee will explore the feasibility of producing a series of texts and computer programs in which the traditional subject matter has been restructured along algorithmic lines so that the computer plays an integral part in the conceptual development of the course content.

3. *Educational Films.* At the 1963, 1964, and 1965 annual meetings of the American Society for Engineering Education, the Commission sponsored a showing of motion pictures of possible use in engineering instruction, collected from government agencies, universities, commercial producers, industry, and specially formed committees. Although this activity is being relinquished to ASEE for its future annual meetings, the Commission's interest in educational films continues to cover a much broader perspective:

(a) A catalog listing all films pertinent to engineering education, classifying them as instructional or documentary, and indicating their level of coverage, i.e., introductory or in-depth.

(b) Identification of areas in which new films should be produced.

(c) A study of the value of the educational film as an adjunct to or substitute for live demonstrations, laboratory experiments, lecturers, and test materials.

(d) The development and use of projection equipment better suited to the needs of engineering educators.

(e) The development of motion picture production methods more suitable for films covering engineering subjects.

4. *Case Studies.* The Commission is currently monitoring, through its National Engineering Case Committee, an NSF-supported pilot project at Stanford University; this project is concerned with the development of case studies to be used by students. By confronting the student with an incident drawn from actual practice, the project places the student in the position of the professional engineer faced with a real problem. The Commission, in light of the potential of this program, is urging further development of the case method and its adoption in other institutions.

5. *Laboratory Equipment Development.* An Advisory Committee of the Commission is preparing a position paper directed toward improving laboratory instruction in engineering schools. In this paper the Committee will describe the function of laboratory instruction, discussing the areas in which additional effort is needed. Specific programs will be outlined and the work which is being done will be described so as to demonstrate the limits of the present accomplishments and indicate future possibilities.

6. *Cooperative Efforts with Industry.* An Advisory Committee of the Commission is giving attention to the matter of interaction between industry and engineering schools. Specifically, it seeks to realize a greater potential from the seminars which industry currently conducts, or from the employment offered to engineers, so that these experiences can broaden a faculty member's technical background enhancing his value in his pedagogical duties at his institution.

The following reports are available from the Commission: "Engineering Conference Report," Boulder, Colo., August 1961; "Annual Report," 1963–64; "Proceedings of Eastern Intercollegiate Conference," May 1964, on Industrialization of Underdeveloped Areas (No. 3); "BUILD Report;" "BUILD Report Systems Engineering" (No. 4); "Impact of Computer Concepts on Engineering Design" (No. 1), by D. M. Baumann, S. J. Fenves, and L. A. Schmit, Jr.

146. Goals of Engineering Education. GEORGE A. HAWKINS (Undergraduate Director), Dean of Engineering, Purdue University, Lafayette, Ind., 47907; JOSEPH M. PETTIT (Graduate Director), Dean of Engineering, Stanford University, Stanford, Calif. 94305. (Grantee: American Society for Engineering Education, 1346 Connecticut Avenue, N.W., Washington, D.C. 20008.) (1963–)

The study is divided into two sub-projects, one for graduate education and one for undergraduate education. The overall study is being conducted through the efforts of an advisory council (Chairman: Eric A. Walker, President, Pennsylvania State University), a roster of organizational representatives, two boards of analysts (one for each sub-project), and institutional committees at all colleges and universities that grant engineering degrees.

The graduate sub-project has as its purpose the investigation and evaluation of graduate work in engineering, in order to formulate objectives and guidelines for the next ten to twenty years. This will be an especially crucial period because of the rapid changes that are occurring in graduate education. In addition, many schools have recently entered, or plan to enter soon, the field of graduate engineering education. These schools seek guidelines for planning their programs.

The undergraduate project is the first evaluation of undergraduate engineering education in about 10 years. Its specific aims include finding answers to these questions: What is required in the education of an engineer to enable him to serve the needs and meet the responsibilities of the engineering profession over the next quarter to half century? What are these needs and responsibilities? Should educational programs for those interested in planning, research, and development be the same as for those whose interests lie in manufacturing, construction, and technical sales?

A report will be prepared to assist those responsible for the design and operation of engineering educational programs. It is also hoped that accreditation groups will find the recommendations helpful in setting forth accreditation objectives and procedures. To predict what type of education will best equip engineering students for the highest professional achievements in the years ahead is hazardous at best, but the report should increase the reliability of the prediction and the value of the educational modifications induced by it.

J. M. Pettit and J. M. Gere, "Evolution of Graduate Education in Engineering," *Journal of Engineering Education* 54, 57 (1963).

J. M. Pettit and J. M. Gere, "Federal Support of Graduate Engineering Education," *Ibid.* 55, 164 (1965).

W. K. LeBold, W. E. Howland, and J. L. McCarthy, "Accreditation Related to Engineering and Graduate Education: A Historical Review," *Ibid.* 55, 175 (1965).

L. Levitas, "Progress Report—Goals of Undergraduate Education," *Ibid.* 55, 217 (1965).

Goals of Engineering Education *Information Documents* include No. 1: "Scope, Organization and Implementation of the Study" (1963); No. 2: "Past Appraisals of Engineering Education and Related Studies" (1963); No. 3: "Initial Charge to the Institutional and Organizational Study Committees on Undergraduate Engineering Education" (1963); No. 4: "Initial Report to the Institutional Committees Concerning Graduate Education in Engineering" (1964); No. 4a: "Analysis of Preliminary Responses to Information Document No. 4" (1964); and "Preliminary Report on Goals of Engineering Education" (1965).

147. Discrete Systems Concepts Project.

JOHN G. TRUXAL, Electrical Engineering Department, Polytechnic Institute of Brooklyn, Brooklyn, N.Y. 11201. (1963–1965)

The broad objective has been to develop teaching material for the introduction of discrete-state system concepts at appropriate places in each year of undergraduate engineering education. Mathematics and engineering departments at the Carnegie, Case, and Illinois Institutes of Technology, Rensselaer Polytechnic Institute, and Polytechnic Institute of Brooklyn have participated in this development.

The developed material consists of a set of fifteen monographs suitable for courses in mathematics or engineering departments at levels ranging from freshman to senior-elective (or perhaps first-year graduate) courses. The monographs, which are available, are:

DSC M–1. *The Impact of Discrete System Concepts on Undergraduate Engineering Education;* Dohrenwend, Elliot, Hrones, Schatz, Truxal.

DSC M–2. *The Application of Discrete State Techniques in Engineering Analysis;* Hoffman, Lavi.

DSC M–3. *Two Detailed Problems Solved with Discrete System Techniques;* Hoffman.

DSC M–4. *Experiments and a Demonstrator for Instruction in Digital System Design;* Roy.

DSC M–5. *Applied Graph Theory for Undergraduate Engineers;* Marshall.

DSC M–6. *Discrete System Techniques at the Sophomore Level;* Braun, Reswick, Truxal.

DSC M–7. *An Undergraduate Program on the Elements of Computation for Engineers;* Braden.

DSC M–8. *State Variable for the Undergraduate;* Truxal.

DSC M–9. *A Digital System Synthesizer for Student Instruction and Research;* Mergler.

DSC M–10. *Computation Developments in the DSC Project;* Slater.

DSC M–11. *Discrete System Concepts in Civil Engineering;* Wang, Werner.

DSC M–12. *An Analog/Digital—Digital/Analog Facility for Laboratory Instruction;* Taft.

DSC M–13. *Elements of Finite-State Machines for Undergraduate Engineers;* Arden.

DSC M–14. *Analog Techniques in Discrete System Analysis;* Hoffman.

DSC M–15. *Discrete State Techniques in Systems and Process Dynamics;* De Russo.

Copies of these monographs may be obtained from the Discrete Systems Project Editor, Case Institute of Technology, Cleveland, Ohio 44108.

148. Engineering Graphics Course Content Study.

PAUL M. REINHARD, Department of Engineering Graphics, University of Detroit, Detroit, Mich. 48221. (1961–1966)

The intent of this study is to evaluate the place of engineering graphics in the over-all picture of engineering education and then to develop timely subject matter to enrich the content of engineering graphics courses. Since one of an engineer's major functions is design, and since graphics can be of significant value in the design function, this study is design-centered.

With the introduction of the graphic aspects of design, graphic analysis, and computer-related graphics, engineering graphics courses can offer freshman and sophomore students engineering experiences having a stimulating and relevant meaning. A digest of applications of graphics in space flight is included to illustrate sophisticated examples of the use of graphics in a modern field of activity. While it is fully realized that each college has its own methods of accomplishing its desired objectives, this project will serve to provide direction to engineering educators who are determined to keep pace with current engineering educational trends.

This study is directed toward alerting both instructor and student to the excitement of contemporary and future technological developments. A series of technical monographs will be published, making new concepts immediately available. These monographs will be written, not only by those primarily interested in graphics, but also by those whose major interest lies beyond the field of graphics. Engineering graphics teachers will find these monographs to be a fertile source of motivating material.

The study has been active with many meetings, seminars, conferences, workshops, and reports involving considerable discussion about graphics in relation to current technological developments. Guidance of the work was by two committees: The Core Committee and the Steering Committee. The Core Committee was made up of graphics teachers who initiated the program and were responsible for details of the work. The Steering Committee was composed of leading industrialists and prominent engineering educators from the degree-granting areas, who provided guidance to the Core Committee and were readily available for consultation. Over 60 engineering educators and practicing engineers, representing 32 accredited engineering colleges and 15 industrial corporations, participated in this course content improvement study.

An editorial committee, responsible for planning and evaluating an engineering graphics paperback series, has negotiated a contract with the McGraw-Hill Book Company for the publication of the following monographs:

F. A. Heacock, *Graphics in Space Flight—A Digest of New Graphic Solutions* (November 1964); R. B. Thornhill, *Graphic Problems for Numerical Control* (in manuscript); S. A. Coons and M. McNeary, *Engineering Graphics in Conceptual Design* (in manuscript); J. R. Burnett and E. C. Zulauf, *Graphic Approach to Analog Simulation* (in manuscript); S. A. Coons, *Graphical Computer Input of Design Concepts* (in manuscript); L. G. Palmer, *Industrial Automated Methods of Graphical Communication* (in manuscript); and W. A. Fetter, *Computer Graphics in Communications* (August 1965).

Other pertinent topics are being investigated for probable development and publication. The technical monographs will provide supplemental instructional material which may be drawn upon to meet the needs of individual instructors. A report, released in May 1965, contains the philosophy of the project, several suggested areas for course content development, course structure, requirements of faculty, conclusions, and recommendations. Copies may be obtained from the project director.

149. Development of an Interdisciplinary Systems Engineering Program. J. W. Mason, Dean of Engineering, K. G. Picha, School of Mechanical Engineering, and J. L. Hammond, Jr., School of Electrical Engineering, Georgia Institute of Technology, Atlanta, Ga. 30332. (1963–)

This project is developing a group of undergraduate courses suitable as electives for students in engineering. Eleven courses are being developed with two specific programs consisting of 10 and 18 quarter hours, respectively, suggested as typical study programs. A maximum of 34 quarter hours of systems elective work will be available to those students who can arrange an elective program of this scope. Program A is designed to give an introduction to systems engineering theory and to provide for participation on a system design team in the case studies course. Program B is a more comprehensive and mathematically-oriented program which provides the basis for advanced study at either the undergraduate or graduate level. This latter program also provides for participation in a case study, and additional work can be added. Plans call for teaching each of the courses at least once during the development phase and preparing notes for those courses for which adequate texts are not available.

Course notes are still in the preliminary stage, but a brief description of the systems program as a whole and of each course has been prepared for student use and is available. Also available are copies of a paper, "Design of an Interdisciplinary Program of Elective Courses in Systems Engineering," J. L. Hammand, Jr., presented at the June 1964 meeting of the American Society for Engineering Education.

Further information may be obtained from Dr. Hammond.

150. Dynamics Course Using Personal Analog Computers. James B. Reswick, Engineering Design Center, Case Institute of Technology, Cleveland, Ohio 44106, and Myron Tribus, Thayer School of Engineering, Dartmouth College, Hanover, N.H. 03755. (1962–1964)

A major goal of engineering education is to bring to the young engineer an understanding of dynamic systems. Modern technology requires him to design and predict the performance of electrical, mechanical, gas, and liquid systems. All engineering curricula contain courses in which students study the formulation and solution of differential equations which characterize such systems. However, while the mathematical expressions are quite manageable, it is difficult to permit students to observe and explore the behavior of a dynamic system in a way that will help bridge the gap between the mathematical model and behavior of the system itself. The analog computer can allow students to experience the performance of a system in a way which gives insight into its behavior.

In order to improve courses concerned with teaching dynamic systems, a versatile, solid-state battery-powered, analog computer system has been developed for use at the undergraduate level in engineering schools. Computer units performing the functions of addition, integration, and multiplication by a constant have been designed to be produced at such low cost that each student in a class may be loaned a set of units sufficient to handle systems described by second-order differential equations and suitable for use at any time or place (e.g., dormitory room, etc.). A meter unit provides battery power and control signals. When simulating a system, a computer can be set to "solve" a problem continuously or in steps of a second or less. A "hold" state permits students to record data at the end of each second or quarter-second of operation. Users of the personal analog computer units need understand only differential equations and functional block diagrams.

A set of course notes designed for use with the personal computer is available on request from Dr. Reswick.

151. Use of Computers and Mathematical Optimization Techniques in Engineering Design.

Donald L. Katz and Brice Carnahan, Department of Chemical and Metallurgical Engineering, University of Michigan, Ann Arbor, Mich. 48104. (1964–)

Engineering design is one area of engineering education which needs substantial bolstering. The introduction of the computer into engineering science (analysis) courses in the engineering curricula will lead naturally to a similar integration into engineering design (synthesis) courses. Many new mathematical techniques are available and under current development for manipulating large quantities of data and for optimization of proposed designs. These should become part of the subject matter treated in engineering design courses.

This project brought together for nine weeks during the summer of 1965 a group of 27 engineering professors, from 23 different schools, who are familiar with engineering design procedures in several subject areas. After studying up-to-date material on data handling, computer simulation, optimization procedures, and industrial design practice, and reviewing current theory and practice in engineering design with computers, each faculty member prepared one or more typical design problems which require the computer or computer-related mathematical optimization techniques for their solution. These design problems, completely solved and documented, are suitable for classroom instruction in the several engineering disciplines.

A group of five faculty members are preparing a syllabus describing the use of computers and optimization techniques in engineering design in the disciplines represented; included will be several of the documented example design problems and their computer solutions.

The final report, to be issued in 1966, will be made available to all engineering schools in the United States.

152. Case Methods for Teaching Engineering.

William Bollay, Design Division, Department of Mechanical Engineering, Stanford University, Stanford, Calif. 94305. (1964–)

Each case being prepared in this project typically describes a current industrial situation where an engineer is faced with an unsolved problem. The problem may be defined explicitly in the case, or be implicit in the circumstances described by the case, or even somewhat mis-defined by characters in the case. The student is to imagine himself in the place of the real-life engineer and develop a solution. He may then be given a sequel to the case telling what the real-life engineer did about the problem and what ensued, possibly leading to another problem.

In this way a student can obtain working knowledge of the crucial stages of several major engineering projects in several different companies in just a few weeks. The episodes can be selected and tailored to particular course objectives. Through cases, students can encounter words of advice and information on "tricks of the trade" from practicing engineers, and they can also examine clinical examples of the way engineering practice is actually carried on.

A variety of case types is being tried in several engineering disciplines and in courses ranging from freshman through graduate levels. Unknown areas being explored include how best to prepare cases, how best to present them, how best to teach with them, and where best to fit them in the engineering curriculum. It is expected that cases may also be useful for research into methodology of engineering practice and as background investigations leading to product innovation or further technical research.

A Selected Bibliography of Engineering Cases, which briefly describes cases prepared at Stanford and elsewhere and tells how they may be obtained, has been prepared and is available without charge from Karl H. Vesper, Director of Case Development, Stanford School of Engineering.

153. Undergraduate Course in Field and Flow Systems.

ROBERT L. SCHRAG, Department of Electrical Engineering, Wichita State University, Wichita, Kans. 67208. (1962–1964)

This project was the development of an interdepartmental course in field and transport phenomena, treating topics in fluid dynamics, electromagnetics, flow through porous media, heat conduction, and diffusion and wave phenomena. The course is designed for the junior level (four credit hours each semester, including a laboratory), and is intended to provide a basic foundation for subsequent courses in each of several engineering departments. Particular emphasis is placed upon unification of treatment with regard to physical principles, solution techniques, and nature of results. However, principles and techniques applicable only to a single discipline are not excluded. Students are assumed to have a background in ordinary differential equations, thermodynamics, and elementary mechanics. The mathematical tools of vector analysis, elementary tensors, and partial differential equations are developed in the course.

The course was developed as a part of an engineering science core program which was adopted in 1959 at Wichita Stae University. For a description of its role in the core program, see: A. T. Murphy, "A Program in Engineering Science for all Engineering Students," *Electrical Engineering* 78, 1006 (1959).

Two volumes of preliminary course notes have been widely circulated. These notes are currently undergoing extensive revision. A few copies of the preliminary notes are still available. Inquiries may be addressed to the project director.

154. Engineering Curriculum Development and Evaluation.

EUGENE HOTCHKISS, Harvey Mudd College, Claremont, Calif. 91716. (1962–1964)

The program seeks an optimal undergraduate foundation for students going on to graduate study in engineering. Initial planning and subsequent curriculum development by the college were much influenced by the "Report on the Evaluation of Engineering Education" (American Society for Engineering Education, Urbana, Ill., 1955). A curriculum study was made possible in the summer of 1958 by a grant from the Fund for the Advancement of Education. Specific features of the curriculum include: allocation of one-third time to the humanities and social sciences; integration of subject matter in mathematics, chemistry, physics, and engineering; an unspecialized engineering curriculum; and continuing emphasis on design. Problems related to the development of the curriculum include determining the performance of students as engineers and scientists in competition with graduates of more conventional curricula, development of an engineering curriculum fostering interest and competence in design, and the development of interest in engineering among freshmen and sophomores. The specific purposes of the program are to improve laboratory work in physics, incorporate computer techniques into all laboratory programs, concentrate on the development of an improved and carefully articulated first-year program, and further strengthen the engineering design program.

As a direct result of this study, the college has established the Engineering Clinic, by which it hopes to encourage teams of professors and students to work together as senior and junior colleagues. The questions faced by these teams will be the sort that professional engineers must face regularly; the solutions they devise may be satisfactory in practice as well as in theory. Other results include a study of the career status of engineering graduates of the college who have been out for one year or more, and the formulation of additional design problems for classroom use.

Results of work done under this program will be submitted to appropriate journals. See also "Engineering Problems at Harvey Mudd College," by W. E. Wilson, presented to the American Society for Engineering Education, U.S. Air Force Academy, Colorado Springs, Colo., June 1962 (available from project director).

155. Development of a Coordinated Program in Field Analysis for Undergraduate Engineering Students.

RAYMOND E. BOLZ, SAMUEL SEELY, and R. E. COLLIN, Engineering Division, Case Institute of Technology, Cleveland, Ohio 44106. (1964–1966)

The purpose of this project is to develop a two-semester junior level lecture course in the broad area of engineering fields and analysis that would be suitable as a core course for engineering students. A preliminary set of class notes is being written. The course will be taught to a small experimental group beginning in fall 1965.

The course aims at integrating the common field concepts and methods of analysis from the areas of fluid flow, heat transfer, electromagnetism, and elasticity. In particular, emphasis is to be placed on the basic formulation of the governing equations, the vector description of field phenomena, and the description and solution of potential flow fields, diffusion, and wave phenomena.

In addition, the basic analytical tools for field analysis are to be developed in a manner suitable for comprehension by junior level students and with sufficient scope and depth to enable meaningful field problems to be solved. Thus, approximate methods for solving Laplace's equation are to be introduced as well as the analytical methods based on separation of variables in rectangular, cylindrical and spherical coordinates, and conformal mapping. The separation-of-variables method will also be extended to the problems of diffusion and wave phenomena.

Inquiries may be directed to Professor Bolz.

156. An Experiment with Laboratory Courses in Engineering.

JOHN S. MCNOWN, School of Engineering and Architecture, University of Kansas, Lawrence, Kans. 66045. (1962–1965)

In this project-type laboratory, the students helped to plan experiments typifying the various objectives of laboratory work: measuring constants, performing calibrations, visualizing unusual occurrences, and gaining insights into unresolved questions. Students successfully conducted such tests in laboratory courses in fluid mechanics, petroleum engineering, chemical engineering, mechanical engineering, and environmental health engineering. Each experience, usually lasting a month or so, was aimed at producing a communication for which the purpose, format, and audience were clearly defined. The Department of English cooperated in the experiment by supplying co-instructors.

157. Interdisciplinary Engineering Laboratory Experiments.

EDWARD F. OBERT and SAMUEL S. LESTZ, Department of Mechanical Engineering, University of Wisconsin, Madison, Wis. 53706. (1961–1962)

A number of low-cost, portable, basic multipurpose experiments have been developed. The objective is to expose students to several areas of knowledge in one experiment, rather than have an experiment in, say, heat power and another experiment in mechanical design. The areas include thermodynamics, heat transfer, stress analysis, statistics, and computers. Specific experiments are also designed to take adavntage of special skills or special interests of the designer.

Analog experiments in heat transfer, along with experiments in fluid friction, dynamics, combustion, transient flow, etc., are included. Laboratory procedures are described. Complete construction drawings are included.

Prior work is described in *University of Wisconsin Engineering Experiment Station Report No. 16*, Part I. The work of this project is covered by Part II. Both publications are obtainable from Dean Robert Marshall, University of Wisconsin, 1513 University Avenue, Madison, Wis. 53706.

158. Investigation of Form Design in Engineering Education.

GEORGE F. WISLICENUS, Department of Aeronautical Engineering, Pennsylvania State University, University Park, Pa. 16802. (1964–1966)

This study is concerned with the scientific and technical content of modern design in engineering and its application to efforts in the teaching of engineering design.

Using existing solutions of related design problems, which are to be gathered during visits to industries, laboratories, and universities in the United States and Europe, the project director plans to interpret and generalize the information gained in such a manner as to permit its application to new design. It is suggested that this can be done by means of similarity considerations and through the recognition of basic design forms described by certain dimensionless design parameters.

A final report will be made available which may be used as a source of information for instructors and thesis advisors, or as a supplementary text for undergraduate and graduate students in the field of engineering design. It is hoped that the report might also serve as a stimulus to scholars in engineering, mathematics, and symbolic logic, to work toward a truly satisfactory methodology of engineering design.

Further information may be obtained from the project director.

Aeronautical Engineering

For additional projects related to this section see also:

172. Structural Dynamics.
173. Demonstration Equipment for Structural Engineering.
174. Experimental Stress Analysis Demonstrations.
175. Transparent Flexible Models for Observation

and Demonstration of Internal Deformation Patterns.

227. Combined Shock Tube, Shock Tunnel, Light Gas Gun, and Hot Shot Wind Tunnel Apparatus.

228. Small Hypersonic Wind Tunnel for Study of Hypersonic Gas Dynamics.

237. Multipurpose Tester for Demonstrations and Investigations of Shock and Vibration Phenomena.

159. Senior Laboratory in Aeronautical Engineering. R. J. H. BOLLARD, School of Aeronautical Engineering, Purdue University, Lafayette, Ind. 47907. (Present address: School of Aeronautical Engineering, University of Washington, Seattle, Wash. 98105.) (1959–1960)

This grant partly supported the development of a senior laboratory. The laboratory, used in a required course in the seventh semester of an eight-semester program leading to the degree of Bachelor of Science in Aeronautical Engineering, consists of twelve challenging experiments: (1) supersonic wind tunnel measurements; (2) low-speed velocity and pressure measurements; (3) low-pressure measurements; (4) hot-wire steady-flow measurements; (5) calibration and transient response of thermocouples; (6) platinum resistance thermometer calibration; (7) total temperature probe calibration; (8) metallographic study of stressed materials; (9) strain measurements; (10) deflection and displacement measurements; (11) measurement of transient phenomena; and (12) beam vibrations.

R. J. H. Bollard, G. M. Palmer, E. C. Brouillette, and W. W. Hill, *A Laboratory for Senior Students of Engineering* (Report No. MISC–60–2, School of Aeronautical Engineering, Purdue University, 1960).

160. Supersonic Streamline Visualization. VINCENT P. GODDARD, Department of Aeronautical Engineering, University of Notre Dame, Notre Dame, Ind. 46556. (1960–1961)

A Mach 1.38 indraft supersonic wind tunnel with a working cross-section of 2½" x 2½" has been modified for streamline visualization by (1) the addition of a large inlet reduction cone, (2) the addition of heavy anti-turbulence screening at the entrance of the inlet cone, and (3) replacement of the solid, one-piece, bottom nozzle block by a block made by sandwiching a ½" sheet of lucite between two 1" metal plates. This arrangement permits indirect illumination of the smoke filaments.

The basic element of the system is a double pass (coincident type) Schlieren with the innovation of a red point source and a circular opaque stop. This modification produces a dark field with a bright shock. The dark field is necessary in order that the proper contrast between the smoke lines and the background be maintained. Nitrous oxide can be used in place of smoke. In this case, the streamlines will be clearly visible along with the shock pattern through any standard Schlieren system.

V. P. Goddard, J. A. McLaughlin, and F. N. M. Brown, "Visual Supersonic Flow Patterns by Means of Smoke Lines," *Journal of the Aero/Space Sciences*, November 1959.

161. Inexpensive Supersonic Wind Tunnel. *(Secondary, College)* GABRIEL D. BOEHLER, Department of Aeronautical Engineering, Catholic University of America, Washington, D.C. 20017. (1959–1960)

A small supersonic wind tunnel which can be built for $300 to $500 has been constructed. The low cost of this tunnel is made possible through the use of a Government-surplus, small, gas-turbine air compressor (AiResearch Model GTC–43–44–6). The tunnel is 2" x 2" in size and is capable of creating air speeds between Mach 1.5 and 2.5 for a period of five to ten minutes.

Plans and details of construction can be obtained from the project director.

162. Lecture Demonstrations in Aerodynamics. ERIK MOLLO-CHRISTENSEN, Department of Meteorology, Massachusetts Institute of Technology, Cambridge, Mass. 02139. (1961–1963)

A small wind tunnel has been built for lecture demonstrations in aerodynamics. The tunnel fits in place of the slide holder of a slide projector. The test sections are interchangeable, and can be changed in five seconds. The test sections contain manometers which project onto the screen pressure distribution and flow over wings and bodies.

A Hele-Shaw apparatus for showing this analogy to potential flow has also been built. This apparatus also fits in a slide projector. Cigarette smoke shows the streamlines. In a few test sections manometers have been included to show pressure drops and the scaling of pressure gradient with channel width, to support the analysis of parallel Poiseville flow behind the Hele-Shaw analogy.

1. *Technology Review*, December 1960.

2. "Apparatus for Lecture Demonstrations in Aerodynamics," *MIT Fluid Dynamics Research Group Report No. 60–2.*

3. For working drawings of slide projector wind tunnel: "Lecture Demonstrations in Aerodynamics," MIT ASRL 1011, June 1963.

4. For working drawings of Hele-Shaw apparatus: "Construction and Use of a Hele-Shaw Apparatus for Lecture Demonstrations," MIT ASRL 1012, June 1963.

Items 2, 3, and 4 are available free from the project director as long as the supply lasts.

Chemical Engineering; Metallurgy; Ceramic Engineering

For additional projects related to this section see also:

143. Pressure-Jump Apparatus for Measuring Rates of Rapid Reactions in Solution.

229. Control System Analog for Teaching Closed-Loop Control Theory.

230. Micropneumatic Breadboards for Fluid Mechanics and Control Laboratories.

163. Objectives for Chemical Engineering. D. L. KATZ, Department of Chemical Engineering, University of Michigan, Ann Arbor, Mich. 48103. (Grantee: American Institute of Chemical Engineers, 345 East 47th Street, New York, N. Y. 10017.) (1959–1960)

The American Institute of Chemical Engineers, through its Committee on the Dynamic Objectives of Chemical Engineering, explored the changes in chemical engineering required by the demands of the future. It concluded that a more science-oriented undergraduate curriculum with emphasis on chemistry should replace the classical applied engineering courses. An intensive program in the fundamentals of engineering sciences is needed to prepare the chemical engineer. A whole new concept of post-college education must be developed. Illustrative sample curricula and descriptions of courses are included in the report, as well as recommendations on how to interest able engineers in teaching.

For a copy of the report, "Dynamic Objectives for Chemical Engineering," *Chemical Engineering Progress* 57, 69 (1961), write to the American Institute of Chemical Engineers.

164. Invisible Fixed and Fluidized Beds for Laboratory Demonstration and Study. H. E. HOELSCHER, Department of Chemical Engineering, Johns Hopkins University, Baltimore, Md. 21218. (1962–1963)

The objective was to develop "invisible" fixed and fluidized beds for laboratory study by undergraduates at the senior level. This system requires that the particles be transparent and of the same refractive index and dispersivity as the liquid flowing through the beds. In such a fixed bed, colored tracers may be used to observe the various flow regimes of interest, and the isotropy of the system can be studied. Through these and other experiments, the entire structure of the fluidized particle system can be examined.

Further information can be obtained from the project director.

165. Experiments to Illustrate the Dynamic Testing of Chemical Process Systems. KARL B. SCHNELLE, JR., Department of Chemical Engineering, Vanderbilt University, Nashville, Tenn. 37203. (Present address: Manager of Education and Research, Instrument Society of America, 530 William Penn Place, Pittsburgh, Pa. 15219.) (1962–1965)

A series of experiments has been developed which attempts to introduce the student to the value of dynamic testing and to the ideas of mathematically modeling a system to determine its parameters. The objective of these experiments is to emphasize the most practical methods of dynamic testing of chemical process equipment. These methods include step testing, steady-state sinusoidal testing, pulse testing, and impulse testing. The experiments are suitable for use in support of an automatic process control course as part of the laboratory experience of students taking such a course.

A report of the experiments is directed to the teacher and is not designed to serve as a text or laboratory manual for students. Instead, the report should be used by the teacher as a sourcebook of ideas which can be adapted to suit the needs of the individual situation. A revised version of this report will be prepared and published by the Instrument Society of America as one of a series of monographs. A limited number of copies of the report are available from the project director.

166. Equipment for Advanced Control and Process Dynamics. BERNET S. SWANSON, Department of Chemical Engineering, Illinois Institute of Technology, Chicago, Ill. 60616. (1960–1962)

Equipment has been developed to provide laboratory instruction in the principles of automatic process control and process dynamics. The equipment provides for analog simulation of processes, determination of controller characteristics, frequency response of simple electrical circuits and a pneumatic control valve, determination of process dynamics and control of a two-stage liquid level system, an air pressure system, and a tube-and-shell heat exchanger. The complete package is described, with the author's results included and sample experiments given. The price for all equipment is approximately $18,000, including a small electronic analog computer.

The analog portion of the work is now available in paperback book form as *Analog Computer Primer,* Swanson and Stice, Blaisdell Publishing Company.

The laboratory experiments are described in a series of articles: Swanson and Stice, "Process Control Laboratory Experiments," *ISA Journal* 12 (1–8), January-August 1965.

167. Optical Analog of Automatic X-Ray Monitor and Control Systems. GEORGE A. PARKS, Department of Mineral Engineering, Stanford University, Stanford, Calif. 94305. (1961–1963)

A simple, flexible, and relatively inexpensive control system which is designed primarily for the use of undergraduate engineering students working independently, has been built. It is based on a continuous on-stream optical reflectivity analyzer and is analogous to commercially available systems utilizing X-ray fluorescence analysis.

The system can be manipulated to illustrate the effects of sustained and transient feed changes, set point and control gap changes and, to some extent, mode of control on quality control and power consumption, and to illustrate system responses such as hunting, cycling, etc. Lags are large and generally not adjustable, hence manipulation is available primarily through the set point and control gap alone.

A paper, "An Automatic Analysis and Control System Adapted to Magnetic Separation for Instructional Laboratory Use," by J. N. Roco, G. A. Parks and B. G. Zambre, has been accepted for publication in the *Transactions of the American Institute of Mining, Metallurgical and Petroleum Engineers,* 1965.

168. Application of Stochastic Processes to Reaction Kinetics. WILLIAM M. MUELLER, Department of Metallurgy, University of Denver, Denver, Colo. 80210. (1963–1966)

The methods of stochastic processes have been applied to studies of the kinetics of chemical and physical phenomena with extremely interesting results. From these studies and from the very nature of stochastic theory applied particularly to time-dependent change, it appears that a course in kinetics (either chemical or physical) should include an introduction to the stochastic approach.

A revision of the present course content of "Kinetics of Metallurgical Reactions" is planned to include: (1) brief background material in probability theory, random sequences and Markov processes, and stochastic and distribution equations selected to provide graduate students in metallurgy, chemistry, and physics with an insight into the stochastic approach; (2) critical reviews providing a basis for further development of the concepts covered in the literature (e.g. the studies reported by Chandrasekhar on coagulation of colloids would be examined for their applicability to precipitation in the solid state); and (3) possible extension to other condensed state phenomena, perhaps to metastable phases, oxidation and corrosion, and grain growth.

169. Study of Ceramic Engineering Education. JOSEPH A. PASK, Department of Mineral Technology, University of California, Berkeley, Calif. 94720. (Grantee: American Society for Engineering Education, 1346 Connecticut Avenue, N.W., Washington, D.C. 20008.) (1962–1963)

Ceramic engineering has traditionally been concerned with the production of non-metallic inorganic products with essentially non-critical specifications, including glass products, refractories, porcelain, pottery, structural clay products, vitreous enamels, and abrasives. Recent developments and critical material needs in space exploration, electronics, and nuclear energy have created new and exacting demands on both the old and new ceramic-type materials. As a result, greater emphasis has been placed on contributions of solid-state science, crystal chemistry, surface chemistry, thermodynamics, etc. Ceramic engineering curricula must incorporate these new developments. The purpose of the study was to outline curricula that reflect these trends.

The final report, *Objective Criteria of Ceramic Engineering Education* (American Society for Engineering Education), is available from Mr. W. Leighton Collins, Executive Secretary, American Society for Engineering Education.

Civil and Sanitary Engineering

For additional projects related to this section see also:

231. Analog Materials for Studying the Plastic Flow of Metals.

241. Transparent Overlay Visual Aids for Engineering Graphics.

250. Photoelastic equipment for Analysis of Structural and Engineering Geology Problems.

170. Undergraduate Curricula in Civil Engineering. FELIX A. WALLACE, Department of Civil Engineering, The Cooper Union, Cooper Square, New York, N. Y. 10003. (Grantee: The Cooper Union; cosponsors: American Society of Civil Engineers and American Society for Engineering Education.) (1959–1961)

Recommendations on civil engineering curricula were evolved by a group of 29 civil engineering educators and practitioners who met in three separate planning sessions. The recommendations were reviewed by 250 participants in a three-day conference held at the University of Michigan. The study recommended that: (1) the undergraduate civil engineering curriculum should be extended to five years; (2) the first three years should comprise a "common" or interchangeable core of subject matter for all engineering students; (3) the fourth year should provide for both terminal and transition students; (4) a degree in civil engineering should be given only at the end of the fifth year; and (5) a general bachelor of science degree may be given at the end of the fourth year. The study also recommended two separate "paths" for graduate work, one leading toward the professional degree of Doctor of Engineering and the other toward the research degree of Doctor of Philosophy.

For copies of the report and further information write to: American Society of Civil Engineers, United Nations Plaza, New York, N. Y. 10017.

171. Dimensional Analysis—Its Application in Mechanics. ROBERT L. KONDNER, Department of Civil Engineering, Northwestern University, Evanston, Ill. 60201. (1963–1965)

The concept and design of experiments and associated apparatus are set forth to illustrate the scientific merits of dimensional analysis as a basic scientific tool that can be applied to studies of engineering instruction and design as related to the fields of mechanics, mechanics of materials, and soil mechanics. Particular aspects of stress distribution, bearing capacity, and photoelasticity are illustrated using a strain-optic analogy device. Many aspects of beam theory, structural models, strength of materials, and structural analysis as affected by load, point of application, material properties, and geometry are illustrated with a cantilevered beam apparatus. Concepts of load-deflection and bearing capacity of footings on sand and cohesive material are studied in footing response experiments. A mechanical device has been designed and built to demonstrate the mathematical and geometric relations between normal and shear stresses as exemplified by Mohr's Circle.

Instruction manuals containing operation instructions, typical experiments, and illustrative examples are being prepared for each device. Further information can be obtained from the project director.

172. Structural Dynamics. GEORGE HERRMANN and JOHN F. FLEMING, Department of Civil Engineering, Northwestern University, Evanston, Ill. 60201. (1963–1967)

A group of models has been designed which demonstrates instability of structures of various shapes under a number of different loading and boundary conditions. Each model has been designed to illustrate a particular type of buckling behavior and to show the effect of changing the variable involved. The specific cases which are demonstrated include transverse and torsional buckling of a column, buckling of a frame, buckling of an arch, buckling of plates, buckling of cylindrical shells, and lateral buckling of a beam.

Additional information is available from the project director.

173. Demonstration Equipment for Structural Engineering. E. H. GAYLORD, Department of Civil Engineering, University of Illinois, Urbana, Ill. 61803. (1961–1963)

1. Elastic theory models. A kit consisting of a portable display board and various splines, junction blocks (joints), relaxation blocks, straining blocks, moment deformers, and shear deformers was developed and manufactured. An almost endless variety of assemblies can be constructed. Incorporation into the model of the appropriate deformers enables one to demonstrate various types of structural behavior to a scale large enough to be seen in the classroom. In addition to showing the deflected shape of various structural forms, the models are useful in demonstrating various mathematical principles and theorems in the field of structural analysis. The models can also be used to demonstrate problems in vibration.

2. Plastic theory models. Demonstration of plastic collapse requires a model which can exhibit to an exaggerated scale the deformed shape of structure after it has passed the stage in its loading history which permits recovery. By making model structural members from aluminum elements (blocks) strung together on rubber tendons, frames can be assembled which demonstrate quite vividly various collapse modes.

3. Photoelastic models. The photoelastic method of measuring strains is usually associated with expensive optical benches and refined techniques for quantitative analysis. The method is ideally suited to order of magnitude demonstrations, but simple, inexpensive deivces for this purpose are not commercially available. An apparatus that can be made in any reasonably well-equipped shop was designed and built.

W. G. Godden, "Demonstration Models for Teaching Structural Mechanics," University of Illinois Engineering Experiment Station Circular No. 78. This circular gives detailed instructions for making the models. It is available from the Publications Office, College of Engineering, University of Illinois.

W. G. Godden, "Models for Teaching Structural Mechanics," *Journal of Engineering Education,* February, March 1963.

174. Experimental Stress Analysis Demonstrations. August J. Durelli, Mechanics Division, The Catholic University of America, Washington, D.C. 20017. (1962–1965)

Experimental techniques are used to help students and designers in the understanding and visualization of stress and strain distribution phenomena. Correlations between the mathematical developments and experimental results are presented, using photoelasticity, mechanical and electrical strain gauges, moiré patterns, and grids.

Elementary polariscopes and simple loading frames have been built using several kinds of plastics and metals. The description of these instruments can be found in "Illustration of Photoelasticity Principles Using Elementary Polariscopes" by A. J. Durelli and V. J. Parks, *Journal of Engineering Education* 54 (8) 290 (1964).

A multipurpose loading device consisting of a frame on the inside of which beams on several supports can be loaded statically or dynamically under bending or torsion has also been built. A large number of problems in elasticity, strength of materials, and strain analysis can be solved using this simple device. Several experimental stress analysis methods are applied and the results compared. A description of the device can be found in "Multipurpose Loading Device" by A. J. Durelli, V. J. Parks, and M. DeMarco, *Journal of Engineering Education* 55 (7) 209 (1965). A detailed report will be prepared with a list of problems and building instructions.

Further information can be obtained from the project director.

174A. Films on Mechanics of Structures and Materials. Robert A. Heller, Department of Civil Engineering and Engineering Mechanics, Columbia University, New York, N. Y. 10027. (1966–1968)

The project is producing six sound films (15–20 min. each) dealing with the phenomenological behavior of structural materials and systems. The films are intended to give the student an intuitive introduction to statics, dynamics, vibrations, stability, and strength of materials and structures by demonstrating these phenomena with dynamic models. A number of the basic principles of mechanics of materials and structures will be demonstrated in films on the following topics: loads and the stability of structures; properties of structural materials, stress and strain; tensile and compressive structures; beams and frames; grids, plates and folded plates; and membranes and shells. These topics are treated without the use of mathematics; the efficacy of the presentation is dependent upon an appeal to the physical intuition of the student. The films will be self-explanatory and usable as a complete sequence or individually.

Further information will be available from the project director.

175. Transparent Flexible Models for Observation and Demonstration of Internal Deformation Patterns. Raymond J. Stith, Department of Civil Engineering and Engineering Mechanics, University of Dayton, Dayton, Ohio 45409. (Present address: Associate Dean, Technical Education, Florissant Valley Community College, Ferguson, Mo. 63135.) (1960–1963)

Transparent flexible models have been developed so that the instructor can demonstrate and the student can visually observe internal deformation patterns. The models are 10" long and have circular (1" diam.), square (1" x 1"), and rectangular (1" x 1½") cross sections. Internal opaque planes make the deformation pattern visible when the members are subjected to flexure or torsion. The models are intended primarily for courses in elementary mechanics of materials to demonstrate conditions under which "plane sections remain plane," a basic assumption in the derivation of elementary solutions. Likewise, the models demonstrate that under some conditions plane sections warp, as in the torsion of noncircular sections. More than fifty engineering schools, technical institutes, and junior colleges have ordered sets of the models.

A report was published in the *Journal of Engineering Education* (November 1963) describing the models and the method of fabrication. A more complete final report is available from the University of Dayton Research Institute.

The models are available from the Ann Arbor Instrument Works, 1200 Rosewood, Ann Arbor, Michigan.

176. Modeling Techniques for Structural Design. Robert J. Hansen, Department of Civil and Sanitary Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 02139. (1961–1963)

The intent of the project was to develop techniques of fabrication and testing of models of structures. The principal product of the project is a report which attempts to summarize and systematize the knowledge that is required for the use of structural models in the education of engineers and architects. The following subjects are treated: the theory of models, model materials, model manufacture, loading and instrumentation, the interpretation of data, demonstration models and typical examples of student research projects. Excluded from the report are the techniques required for intricate design or research projects.

The report is available as Research Report R64–03 from the Department of Civil Engineering, Massachusetts Institute of Technology.

177. Electronic Analog Teaching Aid for Mathematics, Science, and Engineering.

(Secondary, College) Paul R. De Cicco, Department of Civil Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 11201. (1960)

A portable electronic analog teaching aid package has been designed for classroom and laboratory to introduce electronic analog techniques in the simulation of systems and solution of problems in science and engineering. The package consists of: (1) a problem board on which are mounted five articulated models for demonstration and study; (2) a transfer or block diagram board with magnetic symbols of computer operational functions; (3) a program demonstration unit; (4) a photographic facsimile of the computer operating panel, the face being markable with crayon to demonstrate wiring techniques; (5) a 15-operational amplifier electronic analog computer with all necessary auxiliary components for problem solution and display; and (6) a computer programing unit for instructor use in demonstrations and for student use in self-checking of problems which contains, in a series of switching circuits, all external components, power supplies, and metering devices needed for rapid programing of the computer. The estimated cost for the teaching aid package, including the basic computer and all other components, materials, and labor is approximately $4,500.

A report is available from the project director. It includes an introduction to electronic analog techniques, description, drawings and photographs of each unit, and a series of typical problems.

178. Vortex Tank Tunnel, Visual Pipe Network, Dynamic Model, and Portable Vibration Simulator.

Raymond R. Fox, Department of Civil Engineering, George Washington University, Washington, D.C. 20006. (1960–1962)

1. *Vortex Tank Tunnel.* An 8″ diameter cylindrical plastic tank is rotated about its axis in a vertical position by a variable speed mixer motor. A thrust bearing supports the weight of the tank and its liquid contents. An overhead horizontal runner with a vertical probe permits plotting of the liquid surface on a vertical plane through the axis. The approximate cost is $250–$300.

2. *Visual Pipe Network.* A rectangular acrylic plastic manifold with a baffle plate has a threaded hole at one end to receive a variety of short entrances and smooth or artificially roughened plastic tubes. Simple static pressure head and flow rate measurements permit calculation of entrance, loss coefficients, and friction factors. Reynold's experiment can also be performed. The approximate cost is $250–$300.

3. *Dynamic Model.* An elastic model of a simplified rigid frame is set into lateral vibration by a modified loudspeaker unit with a variable-frequency vibration driver. Phase relations and damping constant may be obtained and such phenomena as beating near resonance displayed. The assembly of the model and its driving coil on a wooden base and backboard is inexpensive. Electronic apparatus for producing the driving power and for amplifying, displaying, or photographing the response signal is generally available in university laboratories.

4. *Portable Vibration Simulator.* Continously variable resistors, decade capacitors, and decade inductors simulate damping, inertia, and spring constant, respectively. A transformer is used to simulate coupling of mechanical systems. The system is designed for use with standard input and output equipment such as voltage generators and oscilloscopes which can be inserted at any point in the network. The unit costs under $100, owing to use of nonprecision components which limit the equipment to qualitative study of systems of interest.

Complete information can be obtained from the project director.

179. Unsteady Flow in A Pipe.

M. R. Carstens, School of Civil Engineering, Georgia Institute of Technology, Atlanta, Ga. 30332. (1962–1963)

A device for the study of unsteady flow in a pipe has been designed, fabricated, and tested. The test section is coupled between the pump and the reservoir. The pump is a piston which reciprocates with simple harmonic motion. Frequency is variable. Piston-motion amplitude and frequency are measured and from these values velocity and acceleration are computed. With simultaneous measurements of pressure at two uniform-flow sections in the test section, drag forces and energy dissipation can be determined. Test sections are not standard. Examples of straight-pipe test sections are included in the report. The pump or driving unit can be fabricated for less than $2,000. Suitable dynamic-pressure-measuring and recording equipment can be obtained commercially for about $3,000.

A report is available from the project director.

180. Pneumatic Loading Device for Pure Deviatoric Loading of Soils. YEHUDA KLAUSNER and DUDLEY NEWTON, Department of Civil Engineering, Wayne State University, Detroit, Mich. 48202. (Dr. Klausner's present address: The Negev Institute for Arid Zone Research, P.O. Box 1025, Beersheva, Israel.) (1961–1965)

The device is a controlled rate of loading system composed of commercially available pneumatic process control units, a specially constructed triaxial cell for testing samples ranging in diameter from 1.5 to 2.8 inches, a panel for volume change measurements, and two liquid supply tanks. The unit, excepting the liquid supply tanks, occupies less than eight square feet of floor space and 55 cubic feet of room volume. A unique feature of the device is the maintenance of a constant "first invariant of stress" of the soil sample by automatically decreasing the confining pressure as the piston pressure increases. The estimated cost is approximately $1,000 to $1,500.

Further information can be obtained from the project directors.

181. Conference on the Graduate Education of Sanitary Engineers. ROLF ELIASSEN, Civil and Sanitary Engineering Department, Massachusetts Institute of Technology, Cambridge, Mass. 02139. (Present address: Department of Civil Engineering, Stanford University, Stanford, Calif. 94305.) (1960)

This conference brought together a group of about 100 sanitary engineers and scientists from the fields of education, industry, consulting engineering, public health, and public works agencies for a three-day discussion of means for raising the educational standards of the sanitary engineering profession and meeting the diverse requirements of the potential employers of sanitary engineers.

Another conference is tentatively planned for 1966. The report of the last conference may be obtained from Mr. Frank A. Butrico, Secretary, American Sanitary Engineering Intersociety Board, Inc., P. O. Box 9728, Washington, D.C. 20016.

Electrical and Electronic Engineering

For additional projects related to this section see also:
261. Automata and Nets.
289. Films on Superfluidity and Superconductivity.

182. Semiconductor Electronics Education Committee (SEEC). CAMPBELL L. SEARLE, Department of Electrical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 02139. (Grantee: Educational Services Incorporated, 55 Chapel Street, Newton, Mass. 02158.) (1961–1965)

The Semiconductor Electronics Education Committee, initially supported by the Ford Foundation, is made up of representatives of 16 academic and 8 industrial organizations who are working together to improve the undergraduate teaching of semiconductor physics, devices, and circuit applications. Taking the transistor as the major semiconductor device, the Committee has developed a teaching program which not only explains, but also demonstrates, introductory semiconductor physics, principles of semiconductor devices, and important features of electronic circuit design employing semiconductor devices. The course especially emphasizes relationships between physical properties of semiconductor components and their circuit applications, with close attention to the corresponding special advantages and limitations.

The Committee has written seven paperback texts, which include laboratory experiments, and three films have been produced. The texts are: R. B. Adler, A. C. Smith, and R. L. Longini, *Introduction to Semiconductor Physics;* P. E. Gray, D. DeWitt, A. R. Boothroyd, and J. F. Gibbons, *Physical Electronics and Circuit Models of Transistors;* C. L. Searle, A. R. Boothroyd, E. J. Angelo, P. E. Gray, and D. O. Pederson, *Elementary Circuit Properties of Transistors;* R. D. Thornton, D. DeWitt, E. R. Chenette and P. E. Gray, *Characteristics and Limitations of Transistors;* R. D. Thornton, C. L. Searle, D. O. Pederson and E. J. Angelo, *Multi-Stage Transistor Circuits;* J. N. Harris and P. E. Gray, *Digital Transistor Circuits;* R. D. Thornton, J. Linvill, E. R. Chenette, H. L. Ablin, A. R. Boothroyd and J. Willis, *Handbook of Basic Transistor Circuits and Measurements.*

Volumes 1, 2, 3, and 5 are now available (John Wiley & Sons, Inc.). Volumes 4, 6, and 7 are in preparation.

The films include: J. I. Pankove and R. D. Adler, *Gap Energy and Recombination Light in Germanium;* J. R. Haynes and W. Shockley, *Minority Carriers in Semiconductors;* and J. M. Early and R. D. Thornton, *Transistor Structure and Technology.*

Pending arrangements for commercial distribution, these films may be purchased or rented from Educational Services Incorporated.

182A. A Computer-Oriented Systems Course. HINRICH R. MARTENS, Department of Electrical Engineering, State University of New York at Buffalo, Buffalo, N.Y. 14214. (1966–1968)

A two-semester, senior level course in systems analysis and design is being developed which will make extensive use of digital and analog computers. A complete set of course notes, the necessary computer programs, and a laboratory program are being prepared. A unique feature of the course will be the unified treatment of modeling and analyzing of continuous, discrete, and continuous-discrete systems. The course is planned as the final two semesters of a four-semester sequence in systems design, of which the first two semesters have already been designed. In this new course the computer will be studied as a computational aid, as a control element, and as an active on-line element in systems. Throughout the project, already available materials will be used wherever possible. The laboratory portion of the course will provide practice in use of computers as well as studies of instrumentation, terminal characteristics, and feedback systems.

Further information will be available from the project director.

183. Educational Films in Electrical Engineering. JOHN G. BRAINERD, The Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia, Pa. 19104. (Grantee: Educational Services Incorporated, 55 Chapel Street, Newton, Mass. 02158.) (1963–)

The National Committee for Electrical Engineering Films (NCEEF) plans to supervise the making of a total of about 750 minutes of film plus such supplementary materials as film loops, slides, books, articles, data sheets, and tables.

The work of NCEEF to the present has included: Final review of a 30–minute film *Electromechanical Waves and Instabilities* (J. R. Melcher, MIT; one of a series of three films on electromagnetic fields, forces, and matter); completion of all experimental setups for filming of another film in the same series (H. H. Woodson, MIT); first review of 30–minute film *Wave Velocities and the Omega-Beta Diagram* (T. Van Duzer, University of California at Berkeley); start of film *Linearity* (L. P. Grayson and W. H. Huggins, The Johns Hopkins University); initiation of film *Modulation* (D. D. Weiner, Syracuse University); completion of script for two 30–minute films *Electrical Instruments* (Glen Glasford, Syracuse University). NCEEF has held two conferences for those interested in the use of computers to produce film results; in addition, one member (W. H. Huggins, The Johns Hopkins University) has devoted most of a sabbatical leave to study of the problem of film representation of dynamic vector fields. Some computer-animated film work (John W. Cowan, Ohio State) has been done in the field of electromagnetic radiation.

184. Systems Engineering in Electrical Engineering Education. JOHN G. BRAINERD, The Moore School of Electrical Engineering, University of Pennsylvania, Philadelphia, Pa. 19104. (1961)

The Workshop on Systems Engineering in Electrical Engineering Education considered systems engineering as a horizontal field cutting across vertically organized fields of engineering, and studied specifically the impact of systems engineering on electrical engineering education. The five-day workshop began August 28, 1961, and was attended by 125 representatives from accredited electrical engineering departments. Speakers presented outlines of both broad general experiences in the area of the topic and specific discussion of so-called "techniques," including value theory and measures of effectiveness, queuing theory, mathematical programing, models and modeling, simulation, operational gaming, etc. Potential effects of the systems engineering concept on courses in engineering economy were evaluated.

The condensed proceedings of the workshop, *IRE Transactions on Education* 5, 55 (1962), may be purchased from The Institute of Electrical and Electronics Engineers, Inc., Box A, Lenox Hill Station, New York, N. Y. 10021.

185. Engineering Educational Development Program. L. W. VON TERSCH, College of Engineering, Michigan State University, East Lansing, Mich. 48823. (1963–)

The project is concerned with the development of a new instructional program in electrical engineering although the intent is also to make the program sufficiently broad to have application in many related disciplines. The program encompasses three principal areas, each of which includes laboratory work.

Systems: The objective of these courses is to present an orderly procedure for the analysis, design, and synthesis of systems of discrete components. This discipline is based on expanded concepts of modern electrical network theory and the related techniques of analysis. The components may vary from specific hardware items of engineering to the more abstract concepts of socio-economic work. Examples will be drawn from all these areas.

Continua: The overall objective of the continua courses is to present a unified treatment of the branches of field theory. Emphasis is on basic concepts and similarities in the mathematical structure of the field equations, the methods of solution, and the general characteristics of the solutions. Applications from electromagnetic, thermal, hydraulic, gravitational, and other systems will be presented.

Materials: These courses will define a discipline giving the electrical, mechanical, and thermal properties of materials, as functions of their chemical composition and of their molecular and atomic structure. The program includes a comprehensive study of particle dynamics, introductory quantum mechanics, and introductory statistical mechanics. The program started on a pilot basis in the 1961–62 school year and moved into a full-scale endeavor with all students entering in the fall of 1964.

The following descriptive material on the work to date is available from the Michigan State University bookstore: R. C. Dubes, *Notes on Probability Theory* (to be published by Prentice-Hall, 1967); J. A. Strelzoff, *Introduction to Continua:Heat, Fluid and Electrodynamics, Part I;* and T. Triffet, *Principles of Mathematical Mechanics.*

186. Development of a Graduate Level Power Engineering Program.

JOHN F. CALVERT, Department of Electrical Engineering, University of Pittsburgh, Pittsburgh, Pa. 15213. (1964–1966)

The purpose of this project is to extend class notes and develop student problems and projects in the areas of electrical power equipment and electrical power systems in order to provide course materials for two two-term graduate sequences in electrical engineering. The intent is to produce a design and project approach not now available in graduate electrical engineering in the power areas.

Problems and projects will be tested by members of the electrical engineering staff at the University of Pittsburgh as they are developed; following any necessary revision, they will be made available to other colleges and universities requesting them.

Further information is available from the project director.

187. Programed Instructional Materials for Undergraduate Electrical Engineering.

EVERARD M. WILLIAMS, Department of Electrical Engineering. Carnegie Institute of Technology, Pittsburgh, Pa. 15213. (1963–1967)

Programed self-instructional materials are being prepared and tested for the complete basic science and analytical method content of two undergraduate electrical engineering courses: (a) a one-semester electromagnetic field theory course and (b) a two-semester "basic" course (circuits, magnetic circuits, instruments, etc.) offered for students in five other engineering departments as well as in electrical engineering. These programed materials are expected to increase the effectiveness of study outside classroom and laboratory hours so that learning within these hours can emphasize the creative application of basic science to new professional problems. To date, programs have been prepared on: constant and time-varying potential difference, current and power in electric circuits, solution of linear ordinary differential equations with constant coefficients, and equivalent circuits and Kirchoff's Laws under steady-state d.c. conditions. Limited quantities of these programs are available for test at other institutions.

E. M. Williams, "Some Experiments with Programed Materials," *Journal of Engineering Education,* 53, 549 (1963).

187A. Curriculum Development in Electronic Technology.

CHARLES M. THOMSON, Electronic Engineering Technology Department, Wentworth Institute, Boston, Mass. 02115. (1966–1967)

The purpose of this project is to develop laboratory experiments in electronic technology. The experiments will be designed to give experience with contemporary methods and instruments and also to lead into the learning of basic theory which will be needed to make use of future developments in technology.

Further information will be available from the project director.

188. All-Solid-State Redesign of a Small Hybrid Analog/Digital Computer for Teaching Statistics and Random Processes.

GRANINO A. KORN, Department of Electrical Engineering, University of Arizona, Tucson, Ariz. 85721. (1965–1966)

The Arizona Pedagogical Expandible (APE) I Computer system supported by the National Science Foundation in 1961–62 combined inexpensive vacuum-tube d.c. amplifiers, sampling switches, and decimal counters into a simple digitally controlled differential analyzer and statistics computer; a simple random-noise generator permitted various experiments with random processes.

APE II will be an improved all-solid-state machine.

Like APE I, the new 12–amplifier machine will also be useful for small-scale simulation of dynamical systems, sampled-data systems, and simple optimization problems; unlike APE I, APE II will also have free digital logic for Boolean algebra experiments.

H. Handler, "A Simple Noise Generator for Random-Process Studies," *ACL Memo* 35 (1962).

H. Handler, "A Timer/Event Counter for Random-Process Studies," *ACL Memo* 39 (1962).

G. A. Korn, "Hybrid-Computer Teaching Aid," *Instruments and Control Systems* 36, 97 (1963).

G. A. Korn, *Random-Process Simulation and Measurements,* McGraw-Hill Book Co. (1965).

G. A. Korn and T. M. Korn, *Electronic Analog and Hybrid Computers,* McGraw-Hill Book Co. (1964).

Reports on APE II will be available from the project director by fall 1966.

189. Combined Teaching-Research Communications Systems Laboratory at the Senior-Graduate Level.

MISCHA SCHWARTZ, Department of Electrical Engineering, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 11201. (1963–1965)

A combined teaching-research communications systems laboratory is being developed. The laboratory and its equipment are used not only for a formal graduate communications laboratory course (EE 743, six hours, once a week, fall semester) but also for M.S., Ph.D., and postdoctoral research work and as a source of experiments for inclusion during the project portion of the Polytechnic's senior year electrical engineering departmet laboratory course. Equipment that has been developed includes: a water tank simulator for random channels; several devices for measuring probability density functions; several types of wide deviation, low-distortion FM generators (carrier frequencies in the 200–1600 kHz range); a plug-board programed set of digital logic cards; a set of inexpensive noise generators (0.1 Hz to 1.5 MHz); a simple, repetitive, easily alterable, 24–digit code generator; and various circuit cards containing such circuits as wide band small signal amplifiers, wide band power amplifiers, 4 mc-gating circuits, pulse slicing and reshaping circuits, sine wave oscillators, AM detectors, FM detectors, etc.

Material now available includes: "An Electronic Probability Density Machine" (submitted to *IEEE Transactions on Electronic Instruments*); "A Wide Band Probability Density Machine Utilizing An Oscilloscope"; "Amplitude Limiting in Transistor Oscillators" (to be published in *IEEE Transactions on Circuit Theory*); "Collector Limiting in Transistor Amplifiers and Oscillators" (submitted to *IEEE Transactions on Circuit Theory*); "Squegging in Transistor Oscillators" (submitted to *IEEE Transactions on Circuit Theory*); *Random Channel Simulation and Instrumentation*—IEEE Communications Conference Paper #G12–65–523, June 1965, IEEE Boulder, Colorado Convention; *Wide Deviation FM Generation;* and *Theory of Tuned Circuit Driven Diode Peak Detectors and Limiters.*

Further information on this material may be obtained from Professor K. K. Clarke, Department of Electrical Engineering, Polytechnic Institute of Brooklyn.

190. Apparatus and Experiments for a Modern Communication Laboratory.

HERBERT B. VOELCKER, Department of Electrical Engineering, University of Rochester, Rochester, N. Y. 14627. (1962–1964)

Apparatus and experiments were developed for teaching modern communication theory to senior undergraduate and early postgraduate students of electrical engineering. The special apparatus includes a Fourier synthesizer, panoramic display unit, relay correlator, and statistical analyzer. Experiments using commercial apparatus, e.g., a panoramic spectrum analyzer, were also developed. The apparatus and experiments are intended for semi-tutorial work in that experimental design depends, to varying extents, on the student's ingenuity; the actual experimental work may take from several hours to several weeks. Certain of the topics, e.g., Fourier analysis and statistical correlation of stochastic signals, are suitable for study by undergraduate physicists and/or engineering science students.

H. Voelcker and I. Trussell, "Development of a Modern Communication Laboratory," *Transactions of IEEE Group on Education* E–7, 166–175 (December 1964). Reprints are available from the project director.

191. Solid-State Pulse-Code Modulation System.

ELLIS F. KING and RICHARD C. MACKEY, Department of Engineering, University of California, Los Angeles, Calif. 90024. (1962–1964)

The purpose of this project was to design and construct a pulse-code system of modulation (PCM) wherein analog signals are periodically sampled, quantitated and coded in a binary system for transmission. It will be used as a lecture demonstration aid and as laboratory apparatus for experimental work where its properties may be exploited in a quantitative study of the principles involved.

The final report, available from the project directors, includes schematics, photographs, component data, and all information necessary to duplicate the equipment developed. Typical student and instructor notes and a representative experiment are also provided. The 130-page document is Report No. 64–51, Department of Engineering, University of California, Los Angeles, "A Pulse-Code Modulation System for Experimental Engineering."

192. Digital-Analog Controller for Sampled Data Systems. Paul M. DeRusso, Department of Electrical Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. 12181. (1961–1962)

A special purpose combined analog and digital computer has been developed which performs the discrete data processing necessary in systems operating on sampled data. The computer samples a signal to form a sequence of numbers at its input, processes this sequence in accordance with a logical program, and applies the resultant sequence to the system. It is designed for use in classroom demonstrations, laboratory experiments, and undergraduate and graduate experimentation. The unit is portable and highly flexible as to choice of sampling rate, logical programs, etc. The intention is to give students a physical experience which will clarify the mathematics of the discrete data systems which they have studied.

Further information can be obtained from the project director.

193. Inexpensive Digital-to-Analog Converter for Curve Plotting with Small Digital Computers. George W. Hughes, Department of Electrical Engineering, Purdue University, Lafayette, Ind. 47907. (1961–1963)

The equipment takes the numerical output of a digital computer, reduces it to a binary paper tape using the normal punching facilities of the computer, then converts this tape to an electrical signal for use in plotting the data point, either on a common camera-equipped oscilloscope or on an available plotting table. The equipment incorporates relays, a low-speed tape reader, and an analog plotting device (such as an oscilloscope) which is assumed to be already available in the laboratory. Cost of the equipment for converting the paper tape signal to an analog signal is approximately $750 if the equipment is made in the institution's own shops.

A report on the project can be obtained from the project director.

194. Prototype Systems Laboratory Employing Electrohydraulic, Hydraulic, and Hydrochemical Components. H. E. Koenig, Department of Electrical Engineering, Michigan State University, East Lansing, Mich. 48824; Hinrich R. Martens, College of Engineering, State University of New York at Buffalo, Buffalo, N. Y. 14214. (1961–1962)

The specific objective is to expand the facilities of an existing electromechanical systems laboratory (see first reference below) by including components as they are commonly encountered in a typical hydraulic control system and by providing for the study of mixed electrical-mechanical, hydraulic systems made up of these components. Provision is made in the design of the connections and the instrumentation for efficient and effective measurement of the complete dynamic characteristics of: (1) the devices as multiterminal components and (2) the performance characteristics of any system composed of a collection of mechanical, hydraulic, and electrical components. One of the main features of the laboratory is that all components are completely compatible. Provision is made for maximum flexibility in their interconnection to form a wide variety of systems.

W. A. Blackwell and H. E. Koenig, "A Combined Machinery and Control Systems Laboratory," *Institute of Radio Engineers Transactions on Education* E–2 (4) (1959). Copies are available from the authors on request.

H. E. Koenig and W. A. Blackwell, *Electromechanical System Theory*, McGraw-Hill Book Co. (1961).

H. E. Koenig, Y. Tokad and H. K. Kesavan, *Analysis of Discrete Physical Systems*, McGraw-Hill Book Co. (in press).

Copies of a 125-page report describing the facility and its objective in the educational program are available on request from the Division of Engineering Research, College of Engineering, Michigan State University. The report includes: (1) a complete description of the facility, with a list of equipment, sources of supply or detail drawings, and approximate cost; (2) techniques and procedures for establishing mathematical models, both linear and nonlinear, or the various system components provided in the facility, including the actual mathematical models of several components; (3) examples of analyses of a typical linear electromechanical and a typical nonlinear electrohydraulic system showing, respectively, a comparison between analog and digital solutions and actual system performance; and (4) a representative sampling of laboratory problems usable in an undergraduate educational program.

195. Equipment and Experiments for a Semiconductor Device Laboratory. ALWYN SCOTT, Department of Electrical Engineering, University of Wisconsin, Madison, Wis. 53706. (1963–1964)

A senior, elective technical laboratory course in semiconductor device fabrication has been developed. The students perform basic measurement experiments (thermoelectricity, Hall effect, four-point resistivity, Haynes-Shockley) followed by three intermediate fabrication experiments (dot alloy tunnel diode, solar cell, oven alloy rectifier diode). These experiments use only dry nitrogen as an inert atmosphere and are quite safe. Students then perform two advanced experiments in epitaxial growth of germanium. The first is *liquid phase* growth of large area tunnel diodes. These junctions are mounted and evaluated electronically. The second is *vapor phase* growth of germanium by hydrogen reduction of germanium tetrachloride. Reports have been prepared describing the construction and operation of the epitaxial growth equipment, and various auxiliary equipment such as wire saw, lapping fixtures, hydrogen soldering jig, etc. Student laboratory manuals are also available.

A. C. Scott and M. J. Shah, "Liquid Phase Epitaxial Growth": A. Laboratory Manual, B. Instruction Book, C. Construction Book. Reports 27a, 27b, 27c, Engineering Experiment Station, The University of Wisconsin.

A. C. Scott, C. G. Hanson, and R. B. Schulein, "Vapor Phase Epitaxial Growth": A. Laboratory Manual, B. Instruction Book, C. Construction Book. Reports 28a, 28b, and 28c. Engineering Experiment Station, The University of Wisconsin.

A. C. Scott, R. J. Proebsting, and M. J. Shah, "Solid State Device Fabrication Equipment." Report 29, Engineering Experiment Station, The University of Wisconsin.

A. C. Scott, "An Undergraduate Semiconductor Device Laboratory" (submitted for publication to the *IEEE Transactions on Engineering Education*).

196. Magnetic Memory Oscilloscope. WALLACE L. CASSELL, Department of Electrical Engineering, Iowa State University, Ames, Iowa 50010. (1961–1962)

This device is a single unit to be used with a conventional oscilloscope to make possible the continuous presentation of a transient. The memory is a frequency-modulated recording and playback system with a magnetic memory element in the form of a 12" closed loop of 1/4" magnetic tape run at 15" per second on a conventional tape recorder. A single recording head is used for both recording and playback, and the electronic circuitry is completely transistorized. The device presents transients over a frequency range from 0 to 1000 cycles per second.

Copies of the project report, "A Small Magnetic Memory for Display of Transients," are available from the Engineering Experiment Station, Iowa State University.

197. Magnetic Network Demonstrator. NEAL A. SMITH, Department of Electrical Engineering, The Ohio State University, Columbus, Ohio 43210. (1961–1962)

This project has developed a group of magnetic circuit parts, consisting of coils and cores, which can be used to demonstrate the physical significance of each element of a general magnetic network and to show how it appears in the equivalent electrical circuit. The experiments can be performed with instruments usually found in well-equipped laboratories, but wattmeters with rather small full-scale readings are also required. A set of laboratory experiments using the equipment has been developed.

The final report, available from the project director, includes all information necessary to duplicate the equipment developed. Copies of lecture notes and laboratory experiments are also included.

198. Device for Displaying Phasors as Directed Lines on an Oscilloscope Screen. GEORGE B. HOADLEY, Department of Electrical Engineering, North Carolina State of the University of North Carolina, Raleigh, N. C. 27607. (1961–1964)

The device being developed may be used with an ordinary cathode ray oscilloscope to give a direct presentation of a phasor quantity as a directed line segment. The length of the line is proportional to the magnitude; and its angle, with respect to a reference line, is the phase angle. The instrument should be as easy to use as an ordinary vacuum-tube voltmeter and give twice as much information with each measurement. The instrument should be accurate to within a few percent over a frequency range of 20 to 20,000 c.p.s. Electronic techniques are employed. The instrument can also be used with an X–Y plotter to plot the locus as a function of frequency of a phasor quantity.

Earlier efforts to develop an instrument of this kind are described by E. A. Walker, A. H. Waynick, and P. G. Sulyer, "Polar Vector Indicator," *Transactions of the American Institute of Electrical Engineers* 68, Part I, 154 (1949), and *Electrical Engineering* 68, 489 (1949).

Further information can be obtained from the project director.

199. Lecture Demonstration Equipment for Courses in Electromagnetic Fields and Waves. *(Secondary, College)*, DENYS O. AKHURST, Department of Electrical Engineering, University of Arkansas, Fayetteville, Ark. 72701. (1962–1964)

More than 40 three-dimensional models were designed and built to illustrate the properties of electromagnetic fields and waves. The models show the strength and direction of the fields, direction being shown by the direction of the field lines, and field strength by density of field lines. Several models have dynamic properties to better illustrate variable and changing properties associated with electromagnetic fields. The models are designed so that, after they have been introduced, they may be passed around the class by hand.

A final report, "Development of Lecture Demonstration Equipment for Courses in the Theory of Electromagnetic Fields and Waves," is available from the project director.

200. Electromechanical Forces and Magnetic Circuits. JOHN F. LAMB and JAMES R. TUDOR, Department of Electrical Engineering, University of Missouri, Columbia, Mo. 65202. (1962–1964)

Equipment for demonstrating both static reluctance torque and electromagnetic torque in rotatable machines was developed and class-tested. Other equipment for demonstrating magnetic circuit and transformer principles was also developed. A system of search coils was employed to show paths of main and leakage fluxes and to demonstrate fundamental principles of transformer and magnetic circuit operation. Effects of different types of transformer loading upon flux distribution in the magnetic circuit and upon leakage reactance can be investigated. Both single core and three-core transformer units were constructed.

This equipment is well suited for instructional purposes in the electrical laboratory of a technical institute or college engineering department.

A final report containing comprehensive and detailed information on this work is given in the publication, "Laboratory Equipment for Demonstrating Electro-Mechanical Forces and Magnetic Circuits," by J. F. Lamb and J. R. Tudor, Engineering Experiment Station Bulletin No. 60, University of Missouri. Copies of this publication can be obtained by writing to: Engineering Experiment Station, University of Missouri.

201. Laboratory Aids for Electrical Engineering. CLIFFORD M. SIEGEL, Department of Electrical Engineering, University of Virginia, Charlottesville, Va. 22903. (1960–1961)

The devices are mounted on standard instrument racks for operation by students outside of regularly scheduled classes and without supervision. One instrument provides a cathode-ray tube display of the current-voltage characteristics of about thirty electron tubes, photo devices, resistors, and semiconductor devices. The student has access to certain controls for selecting the device for study and to others for manually varying such parameters as temperature, grid voltages, emitter currents, and light intensity, as desired. Another instrument demonstrates voltmeters responding to eight different properties associated with each of eight different waveforms of voltage. The third demonstrates a variety of single-phase and polyphase transformer connections, rectifier circuits, and filter circuits. Each instrument requires about $300 for parts and about two weeks' construction time; each weighs 20–30 pounds.

One report provides a description of all three instruments. Each is described further by a separate report containing, typically, 15 pages of detailed instructions for construction, an explanation of operation of the instrument, five to ten pages of schematic diagrams, and ten full-scale pictorial layout and wiring diagrams. The reports can be obtained by writing to the project director.

202. Automatic Plotting of Phase, Gain, and Root Locus from Pole-Zero Constellations. BROTHER C. ALBERT WELSH, Department of Electrical Engineering, Manhattan College, Bronx, N.Y. 10471. (1962–1964)

The apparatus gives a direct plot of gain vs frequency and of phase vs frequency on a dual beam oscilloscope from an s plane plot of the poles and zeros of any transfer function. An alternative form of this apparatus gives the root locus directly and automatically. The design is refined so that faculties and students at other institutions can build the apparatus.

Further information can be obtained from the project director.

Industrial Engineering

203. Punched-Tape Numerically Controlled Machine Tool. FRANK W. TIPPITT, Department of Industrial Engineering, Southern Methodist University, Dallas, Tex. 75222. (1960–1961)

The machine tool system consists of a seven-channel punched-tape reader, logic and control units, a three-axis worktable, and a display panel. It is compatible with any electromechanical punched-tape reader known to be available. The logic and control unit has been designed for both chassis-socket and printed circuit construction. Semiconductors are used throughout. Expansion of the system to a larger scale is possible. At present, simultaneous motion by two axes is not provided but can be installed with simple duplication of circuit designs used. The system is being extended to incorporate part of an IBM-650 system for on-line digital control. This change emphasizes the research capability to the detriment of the basic teaching aid.

A final report is available from the project director.

203A. Films on Manufacturing Engineering. Julian R. Frederick, Department of Mechanical Engineering, The University of Michigan, Ann Arbor, Mich. 48104. (1966–1969)

Four 15-minute films on technical processes are being prepared for engineering and technical institute students. Each film will treat a single manufacturing process, such as casting, welding, hot and cold working, machining, powder metallurgy, or shaping of polymers. Emphasis in the films will be on the basic engineering principles involved in the subject process, but the manufacturing operations and hardware will also be shown. The films will be made from existing footage produced by various industrial organizations; diagrams will be added and an entirely new narration will be written. Supplementary notes for the instructor will be provided with each film.

Further information will be available from the project director.

204. Waiting-Line Simulator. Scott Tabor Poage, Engineering Research Division, Oklahoma State University, Stillwater, Okla. (Present address: Industrial Engineering Department, Arlington State College, Arlington, Tex. 76010.) (1960–1962)

This is a device to demonstrate the action of queues (waiting lines) and to enable the student of queuing theory to apply that theory by the analysis of data from the electromechanical demonstrator.

Further information can be obtained from the project director.

205. Augmented Queuing System Simulator. Paul E. Torgerson, School of Industrial Engineering and Management, Oklahoma State University, Stillwater, Okla. 74075, and Charles Burford, Department of Industrial Engineering, Texas Technological College, Lubbock, Tex. (Grantee: Oklahoma State University.) (1963–1964)

Several single facility queuing systems are combined through an interconnecting device to give an augmented system which will permit simulation of complex series and parallel operations. The equipment will be useful in both undergraduate and graduate courses in operations research and queuing theory.

Further information can be obtained from the project director.

206. Portable Force-Platform for Measuring Bodily Movements. J. W. Barany, Department of Industrial Engineering, Purdue University, Lafayette, Ind. 47907. (1961–1962)

The force-platform is suitable for studying the forces and human effort required to perform various types of muscular work. The device measures human forces in three components. It is portable, inexpensive to build, and suitable for laboratory demonstrations and experiments for undergraduate courses in work methods and measurement, human engineering, and job design. Standard recorders of the Sanborn type are used with the platform to obtain force traces.

James W. Barany and James H. Greene, "The Force-Platform: An Instrument for Selecting and Training Employees," *American Journal of Psychology* 74, 121 (1961).

An abstract of the final report is available from the project director.

Materials Science; Materials Engineering

For additional projects related to this section see also:

185. Engineering Educational Development Program.
203A. Films on Manufacturing Engineering.
231. Analog Materials for Studying the Plastic Flow of Metals.
233. Equipment for a New Strength of Materials Laboratory.
234. Multi-Functional Machine for Materials Testing and Processing Experiments.
246. High Pressure Triaxial Apparatus for Geology, Geophysics, and the Engineering Sciences.

207. Science of Materials Laboratory Experiments. Glenn Murphy, Department of Nuclear Engineering, Iowa State University, Ames, Iowa 50010. (1963–1966)

The objective of this project is to develop a set of laboratory experiments for the field of science of materials. Although there are new approaches to the classroom teaching of materials from a scientific rather than a purely descriptive point of view, a need exists for modernized laboratory experiments designed to emphasize concepts, laws, and principles in this field. Simplicity, ease of construction, and elimination of unproductive detail will be emphasized. Table-top and small-scale devices and systems will be used where possible. Experiments will include demonstrations, student participation exercises, and independent study problems. The experiments are being run on a trial basis in current courses.

A set of laboratory experiments is planned for publication.

208. Projection Slides for Materials Science. JOHN C. SHYNE, Department of Materials Science, Stanford University, Stanford, Calif. 94305. (1961–1964)

The aim of this program is to develop a set of about 200 projection slides demonstrating metallurgical microstructures. The slides illustrate important aspects of the subject matter taught in undergraduate level physical metallurgy courses. Sets of the photomicrographs in the form of projection slides (either 35mm or 3¼" x 4") can be made up for distribution to interested institutions.

Further information can be obtained from the project director.

209. Lecture Demonstration Equipment for Materials Science. JOHN E. DORN, EARL R. PARKER, and JACK WASHBURN, Department of Mineral Technology, University of California, Berkeley, Calif. 94720. (1962–1963)

This project developed lecture-demonstration models that illustrate the scientific principles on the basis of which the useful properties of materials are correlated with atomic crystal and microstructure.

Further information may be obtained from the project directors.

210. Atomic and Molecular Relationships in the Study of Properties of Engineering Materials. GEORGE N. BEAUMARIAGE, JR., Department of Mechanical Engineering, Sacramento State College, Sacramento, Calif. 95819. (1960–1963)

1. Special overlays for use with an overhead projector have been made to teach phase diagrams. These 8" x 10" overlay sets are available at cost for the following diagrams: Fe-C, Na_2O-SiO_2, Fe-O, CaO-Al_2O_3-SiO_2, SAE 4130 steel.

2. Special small heat-treating furnaces (range 0° to 2200°F) have been built for heat-treating small samples. A major value of these furnaces is the ease and speed with which the required heat-treating temperatures can be reached.

3. A new electric radiation-type furnace has been designed to accommodate large samples under a new range of conditions.

Further information can be obtained from the project director.

211. Microscopy in Teaching the Science of Solids. *(Secondary, College)* KENNETH E. ROSE, Department of Metallurgy and Materials Engineering, University of Kansas, Lawrence, Kans. 66045. (1962–1966)

The objective is to prepare a set of working outlines which will enable students and teachers to demonstrate and observe, by means of a microscope or microprojector, the formation and growth of crystals, the behavior of single and multiple component systems, plastic deformation, recrystallization, and polymorphic transformations. A distinct feature of the demonstrations is the small amount of time required; since most of them can be completed in five or ten minutes, they help to identify the phenomena as dynamic events involving phase changes and movement of atoms. Simple, readily available apparatus and nonhazardous reagents will be employed.

Basic techniques are described in E. M. Chamot and C. W. Mason, *Handbook of Chemical Microscopy*, John Wiley & Sons (1951). Further information can be obtained from the project director.

212. Education in Wood Science and Technology. EVERETT L. ELLIS, Forest Research Laboratories, P. O. Box 571, Corvallis, Ore. 97330. (Former director: George A. Garratt.) (Grantee: Society of Wood Science and Technology, P. O. Box 5062, Madison, Wis. 53705.) (1960–1962)

The study surveys the present status of professional education in wood science and technology and makes recommendations for the future. It is intended to provide the information and incentive needed for professional upgrading and particularly for enhancement of education in wood science and technology through strengthening the scientific bases on which the profession rests.

A final report has been published by the Society of Wood Science and Technology. Further information may be obtained from the project director or from the executive secretary of the Society.

213. The Mechanism of Moisture Movement in Wood. William M. Harlow and Christen Skaar, Department of Wood Products Engineering, State University College of Forestry at Syracuse University, Syracuse, N. Y. 13210. (1960–1963)

This 30-minute 16mm, sound-color film illustrates the complexity of wood structure and how moisture moves through it in capillary, hygroscopic, and vapor form. Both animation and time-lapse photography are used extensively. The film is intended for wood technology, engineering, and architecture students, and any others who use wood as a construction material.

Film distribution: Film Library, State University College of Forestry at Syracuse University.

Mechanical Engineering; Solid and Fluid Mechanics

For additional projects related to this section see also:

171. Dimensional Analysis—Its Application in Mechanics.

172. Structural Dynamics.

185. Engineering Educational Development Program.

194. Prototype Systems Laboratory Employing Electrohydraulic, Hydraulic, and Hydrochemical Components.

250. Photoelastic Equipment for Analysis of Structural and Engineering Geology Problems.

289. Films on Superfluidity and Superconductivity.

299. Study of the Teaching of the Physics of Fluids in American Universities.

214. Demonstration-Experiment Films in Fluid Mechanics. Arthur E. Bryson, Division of Engineering and Applied Physics, Harvard University, Cambridge, Mass. 02138. (Grantee: Educational Services Incorporated, 55 Chapel Street, Newton, Mass. 02158, for the National Committe for Fluid Mechanics Films.) (1961–)

The Committee is a self-constituted group of professors who have undertaken to produce college-level films based on experimental demonstrations in fluid mechanics. These films are designed to help students in engineering and physics to relate the classroom presentation of symbols, equations, and words to the physical phenomena of fluid mechanics.

The films in no way compete with laboratory instruction. On the contrary, they should eliminate the tendency to include demonstration experiments in the laboratory and thus permit the instructor to focus on the more important aspects of laboratory investigation, namely, developing new knowledge and solving problems by experimental means.

Two classes of films are being produced. Some 25 half-hour films with sound will present comprehensive experimental expositions of various concepts or themes in fluid mechanics. In addition, a hundred or more four-minute cartridge loops will be produced, each providing an experimental demonstration of a specific point. The loops are used with a special projector.

Thirty-minute sound films currently available include: *The Fluid Dynamics of Drag, Vorticity, Flow Visualization, Deformation of Continuous Media, Pressure Fields and Fluid Acceleration, Surface Tension in Fluid Mechanics, Waves in Fluids, Secondary Flow, Rheological Behavior of Fluids, Boundary Layer Control.* Thirty-minute sound films in preparation include: *Magnetohydrodynamics, Channel Flow of a Compressible Fluid, Fundamentals of Boundary Layers, Low Reynolds Number Flows, Eulerian and LaGrangian Descriptions, Flow Instabilities, Cavitation, Rarefied Gas Dynamics, Fluid Motion in Rotating Systems, Flow of Stratified Fluids, Supersonic Gas Dynamics, Forces on Bodies, Sound Generation, Free Convection, Turbulence.* Approximately 44 four-minute silent films are currently available. Film distribution: Encyclopaedia Britannica Films, Inc.

A. H. Shapiro, "Educational Films in Fluid Mechanics," lecture before Institution of Mechanical Engineers, Cambridge, England, April 1964. (Reprints available from Educational Services Incorporated.)

F. A. Schraub, S. J. Kline, J. Henry, P. W. Runstadler, A. Littell, "Use of Hydrogen Bubbles for Quantitative Determination of Time Dependent Velocity Fields in Low Speed Water Flows," American Society of Mechanical Engineers Paper No. 64–WA/FE–20.

W. H. Heiser, "Influence of Magnetic Fields upon Separation," *Journal of American Institute of Aeronautics and Astronautics* 2 (12) (1964).

A. H. Shapiro, "Motion Pictures for the Engineering Sciences," *Journal of Engineering Education* 52 (7) (1962).

215. Films on the Mechanics of Fluids. Hunter Rouse, Institute of Hydraulic Research, University of Iowa, Iowa City, Iowa 52241. (1960–)

Six 20-minute sound films, in color, are being produced to cover the following material: (1) an introduction to the mechanics of fluids stressing the breadth of this field of knowledge, the necessarily close tie between theory and experiment, the role of the scale model in engineering analysis and design, and methods of flow measurement in laboratory and field; (2) the source and significance of the fundamental principles of continuity, momentum, and energy, and their application to typical problems in many professional fields; (3) gravitational phenomena including jets, nappes, channel transitions, waves, surges, and effects of density stratification; (4) effects of viscosity, examples of laminar flow, characteristics of fluid turbulence, and problems of surface resistance; (5) form drag and lift and their application to propulsion and fluid machinery; and (6) compressibility effects—water hammer, submarine signalling, gravity-wave and sound-wave analogies, and supersonic drag.

The first four films (all 16mm) have been released, and the fifth is nearly completed; they are: *Introduction to the Study of Fluid Motion* (24 min.), *Fundamental Principles of Flow* (23 min.), *Characteristics of Laminar and Turbulent Flow* (26 min.), *Fluid Motion in a Gravitational Field* (23 min.), and *Form Drag, Lift, and Propulsion.*

Film distribution: Audiovisual Center, Division of Extension and University Services, University of Iowa.

216. Motion Pictures in Fluid Mechanics.

EDWARD SILBERMAN, St. Anthony Falls Hydraulic Laboratory, University of Minnesota, Minneapolis, Minn. 55414. (Former director: Lorenz G. Straub, deceased.) (1960–1962)

The film, *Fluid Mechanics—The Boundary Layer* (16mm, sound-color, 30 min.), contains a series of experimental demonstrations intended to supplement classroom work and textbook explanations. The flow demonstrations are correlated with graphs and sketches to make continuous orderly presentation. The subject matter of the film falls into four main sequences as follows: (1) the boundary layer of a flat plate (12 min.); (2) boundary layers and pipe flow (6 min.); (3) separation of the boundary layer (7½ min.); and (4) roughness in the boundary layer (4½ min.). Several additional films on fluid mechanics are planned.

Rental or purchase of films for educational showings: The St. Anthony Falls Hydraulic Laboratory.

217. Film on Mechanism of Plastic Deformation During Chip Formation.

JOSEPH DATSKO, Department of Mechanical Engineering, University of Michigan, Ann Arbor, Mich. 48104. (1965–1966)

The purpose of this project is to contribute to the improvement of courses on manufacturing processes by preparing a 30-minute motion picture showing the mechanism of plastic deformation during machining. The film will be based on a 15-minute silent film which will be expanded to 30 minutes; a narration will be added so as to increase its usefulness in teaching. Production will be handled by the Department of Photographic Services at the University of Michigan. The film and accompanying printed material will be distributed under appropriate commercial arrangements.

218. A Modern Undergraduate Mechanical Engineering Measurement Laboratory.

RAYMOND COHEN, School of Mechanical Engineering, Purdue University, Lafayette, Ind. 47907. (1962–1965)

The object of this project was to develop general purpose equipment and experiments suitable for an undergraduate laboratory course emphasizing problems of dynamic measurements. The pieces of equipment include a rocket cart of approximately 150 lbs. in weight; an inexpensive constant volume combustion bomb; a landing gear simulating the tail wheel of a small airplane during touchdown; a small instructional, low-cost shock tube; and a simple laboratory mounting which allows determination of the natural frequencies of a small refrigerator reed valve throughout the entire audible range.

A report describing the apparatus used, suggesting experiments, and giving some typical results will be distributed to the deans of faculties of engineering colleges. Additional copies will be available in limited numbers from the project director.

219. Development of a Modern Senior Mechanical Engineering Systems Laboratory.

W. B. COTTINGHAM and C. F. WARNER, School of Mechanical Engineering, Purdue University, Lafayette, Ind. 47907. (1963–1964)

The general objective of the project was to design engineering systems incorporating mass-produced items and to develop experiments which would evaluate the performance of the systems and of single components under a variety of conditions. Simple dynamic systems consisting of matched and mismatched components were included. Operating characteristics of such items as vacuum cleaners, humidifiers, automatic projectors, electric drills, and thermoelectric refrigerators are predicted in the design class and then verified in the laboratory.

The equipment and projects will be described in a report to be issued by the School of Mechanical Engineering, Purdue University. Further information can be obtained from the project directors.

220. An Undergraduate Heat and Mass Transfer Laboratory. P. W. McFadden, School of Mechanical Engineering, Purdue University, Lafayette, Ind. 47907. (1962–1964)

Equipment and student-participation experiments being developed are as follows: (1) an inexpensive supersonic blowdown wind tunnel system (1½"x3½" test cross section) for heat, mass, and momentum transfer analogy; (2) an inexpensive optical system capable of separating the D-lines and rugged enough for student use for measurement of flame temperatures; (3) a simple, single-fluid heat exchanger with control system capable of controlling power input, inlet velocity, and inlet fluid temperature with time for steady state and transient analysis; and (4) a student interferometer for steady state and transient binary gas diffusion studies.

The equipment and experiments will be described in a report to be issued by the School of Mechanical Engineering, Purdue University. Further information can be obtained from the project director.

221. Laboratory Experiments in Heat Transfer and Fluid Mechanics. Fred Landis, Department of Mechanical Engineering, New York University, New York, N. Y. 10053. (1961–1963)

Information on significant and novel experiments in the areas of heat transfer and fluid mechanics has been collected on a nationwide basis, evaluated, and distributed. The final report lists educational objectives, underlying theory, construction details, suppliers (where appropriate), and procedures to allow interested schools to construct similar equipment for their own use. Experiments cover the following areas: conservation laws in fluid mechanics; rotating systems and vortex motion; transient fluid mechanics, transition, viscous effects; compressible flow and gas dynamics; temperature; heat transfer and heat flux measurements; conduction heat transfer and fin analyses; conduction heat transfer analogs; radiation heat transfer; convective heat transfer; two-phase heat transfer; heat exchangers; determination of thermodynamic properties; special projects; miscellaneous demonstrations; instruments and equipment.

F. Landis (ed.), *Laboratory Experiments and Demonstrations in Fluid Mechanics and Heat Transfer*, New York University, New York, 1964.

222. Experimental Mechanical Engineering. G. L. Goglia, Department of Mechanical Engineering, North Carolina State of the University of North Carolina, Raleigh, N. C. 27606. (Present address: School of Engineering, Old Dominion College, Norfolk, Va. 23508.) (1960–1962)

This project involved: (1) study of the objectives of experimental mechanical engineering in the whole curriculum; (2) careful search of departments of mechanical engineering to discover unusually successful low-cost experiments which meet these objectives; (3) design of new, low-cost, non-commercial experiments which appeal to students' creativity and exemplify important principles developed in theory courses; (4) preparation of drawings and specifications, and the fabrication of prototypes of equipment for these experiments; (5) testing and improvement of experiments by the use of prototypes under actual instructional conditions; (6) preparation and distribution of a manual setting forth outlines of experiments, drawings of equipment, and specifications of equipment to interested departments of mechanical engineering in the United States.

Copies of the manual may be obtained by writing directly to Professor N. W. Conner, Director of Engineering Research, North Carolina State University.

223. Educational Aids in Mechanical Engineering. T. E. Jackson, Department of Mechanical Engineering, Lehigh University, Bethlehem, Pa. 18015. (1960–1962)

The purpose of the project is the improvement of undergraduate mechanical engineering laboratory courses, and the development of "bench-type" equipment for use in the laboratory or for demonstration in the classroom. A bibliography of current publications applicable to the philosophy of the laboratory has been prepared, as well as actual laboratory problems. A list of suppliers of various pieces of equipment, components, and instrumentation especially suitable to this type of laboratory work is also available. Shop drawings of some of the equipment that has been constructed and tested in the student laboratory are included in the report.

224. Energy Conversion Devices. H. Dean Baker, Department of Mechanical Engineering, Columbia University, New York, N. Y. 10027. (Former director, Robert A. Gross.) (1961–1963)

Five energy conversion devices have been built for use in undergraduate engineering laboratory instruction:

1. *A Solar Solid-State Electric Energy Converter.* Principles of radiant energy measurement, irreversible thermodynamics, elementary solid-state theory, and the laws of thermodynamics are illustrated.

2. *A Plasma-Diode Energy Device.* A simple plas-

ma diode illustrates some basic properties of hot, radiating surfaces, ionization at surfaces, space charge neutralization, and some simple properties of a plasma.

3. *Thermoelectric Coolers.* Undergraduate student laboratory exercises are provided with complete directions for assembling the required equipment, with full instructions as to procedure in the form intended to be used by the students themselves, and with sample results for each experiment.

4. *Fuel Cells.* Theory, experimental apparatus, and experimental results are described for fuel cells. Student laboratory exercises are indicated with complete directions for assembling and operating the required equipment.

5. *Propulsion Nozzle.* Theory, experimental apparatus, and experimental results are described for a Mach-2 propulsion nozzle.

Reports on these items are available from the project director.

225. Experiments on Coupled Flows in Solid-State Devices. Stanley W. Angrist, Department of Mechanical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. 15213. (1963–1966)

A laboratory device has been built which allows the student to verify Kelvin's second relation; this relation describes the coupling between the Seebeck and Peltier coefficients. Laboratory experience with this experiment has shown it to be an effective introduction to some of the material needed to understand direct energy conversion in solid-state devices and the thermodynamics of coupled phenomena. Work is now under way on developing a device which would allow the student to verify the Bridgman relation, the equation analogous to Kelvin's second relation that holds when a solid is subjected to a magnetic field.

The results of the first phase of the work are completely described in: S. W. Angrist and M. Vallidis, "An Experiment in Coupled Flows," *Journal of Engineering Education* 55 (9), 257 (1965).

The experimental apparatus described will be commercially available from The Ealing Corporation.

226. Apparatus and Experiments in Magnetogasdynamics. Ali Bulent Cambel and Thomas P. Anderson, Department of Mechanical Engineering and Astronautical Sciences, Gas Dynamics Laboratory, Northwestern University, Evanston, Ill. 60201. (1961–1965)

Prototype experiments have been developed in magnetofluidmechanics for advanced undergraduate and/or beginning graduate students. Use of these experiments is anticipated in experimental engineering courses in energy conversions, measurements, and interdisciplinary topics. Diagnostic as well as system studies have been planned for use with both steady state as well as transient plasma phenomena.

Ali Bulent Cambel, "Magneto-Gasdynamics: Its Science and Technology," *American Scientist* 50 (3), 375 (1962).

T. P. Anderson, "Magnetohydrodynamics and Magnetoaerodynamics," Chapter 1 of *Plasma Technology: Aerospace Applications*, J. Grey (ed.), Prentice-Hall, Inc., to be published.

Magnetohydrodynamics, a 16mm sound film, is available upon request.

Further information can be obtained from the project directors.

227. Combined Shock Tube, Shock Tunnel, Light Gas Gun, and Hot Shot Wind Tunnel Apparatus. E. K. Parks and R. E. Petersen, Department of Aerospace and Mechanical Engineering, University of Arizona, Tucson, Ariz. 85721. (1961–1963)

The apparatus consists of a shock tube of small cross section (approximately 4" x 4") composed of six sections having a total length of about 20'. One of the sections is provided with windows for optical viewing. An arc chamber, a launch tube, and a de Laval nozzle can also be used in conjunction with certain sections of the basic shock tube to adapt the apparatus to use as a shock tunnel, light gas gun, or hot shot wind tunnel. The cost of the partially instrumented apparatus is estimated at $2,000, if fabricated by the university. Additional instrumentation (e.g., piezo pressure, temperature, etc.) could increase the cost by $3,000.

Parks and Petersen, "A Versatile Shock Tube Facility," Engineering Experimental Station, University of Arizona, EES Report No. 3 (1964).

Further information can be obtained from the project directors.

228. Small Hypersonic Wind Tunnel for Study of Hypersonic Gas Dynamics. John A. Fox, Department of Mechanical and Aerospace Sciences, University of Rochester, Rochester, N. Y. 14627. (Original grantee: Pennsylvania State University.) (1960–1963)

The tunnel, a small hypersonic wind tunnel, uses an electric arc for gas heating purposes. The design Mach numbers are approximately 4 and up. Only minor difficulties have been encountered in operation. One problem currently faced is the construction of higher Mach number nozzles.

A report on design and construction of the tunnel is available from the project director.

229. Control System Analog for Teaching Closed-Loop Control Theory.

LESLIE M. ZOSS, Department of Mechanical Engineering, Valparaiso University, Valparaiso, Ind. 46383. (1961–1964)

The purpose of the project was to develop a control system analog for use in teaching the fundamentals of closed-loop control theory. This analog, useful in both demonstration and experimentation, helps in teaching such fundamental control concepts as controller selection, controller adjustment, control loop stability, rise time, overshoot, offset, and the effect of a disturbance and load change. Basic theory of closed-loop control may be explained by using only this single piece of equipment.

Copies of the construction report and experiments covering a semester's work are available from the project director. The experiments include student instruction sheets, detailed reports on actual experiments, and instructor's notes. The control system analog may be purchased from Philco Techrep Division.

230. Micropneumatic Breadboards for Fluid Mechanics and Control Laboratories.

(Secondary, College) JOSEPH MODREY (present address: Mechanical Engineering Department, City and Guilds College, London, S.W.7, England), and W. A. AUBREY, Department of Mechanical Engineering, Union College, Schenectady, N. Y. 12308. (1962–1963)

Pocket-size models have been developed to replace to some degree the massive plumbing system typifying present fluid mechanics laboratories. Instead of pipes, etc., passages are made by cutting grooves in illustration board or metal. Orifices, restrictors, plenums, etc., are formed by silhouetted channels about 1/16" deep and to scales 1/10 to 1/100 of present laboratory equipment. Because of low cost and ease of modification of the models, students should enjoy more freedom for personal explorations. The models will be most useful at the junior and senior levels of fluid mechanics, vibration, design, and control courses.

Further information can be obtained from the project directors.

231. Analog Materials for Studying the Plastic Flow of Metals.

MILTON C. SHAW, Department of Mechanical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. 15213. (1961–1965)

A number of experiments are being designed and apparatus assembled to illustrate the main features of the plastic flow of materials when subjected to large plastic strains. By using plasticine and wax as analog materials for metals, it is possible to reduce the forces the equipment must withstand by about three orders of magnitude. The apparatus is being designed to be as inexpensive as possible so that each student may be supplied with his own kit.

A final report will soon be available for distribution without cost. A text based on these results for use in advanced laboratory programs in plasticity and including theoretical background, selected reading program, and suggested experiments is now being written. This report should be available in 1966 under the title "Applied Plasticity." A 16mm silent film that runs 12 minutes will also be available at a cost of $20 per copy. The film shows the progressive deformation of initially square grids on the meridian planes of specimens tested in compression, hardness, and piercing.

Further information can be obtained from the project director.

232. Take-Home Kits for Experiments in Engineering.

WALTON FORSTALL, Department of Mechanical Engineering, Carnegie Institute of Technology, Pittsburgh, Pa. 15213. (1962–1965)

Take-home experiments have been developed which can be used in courses on fluid mechanics, kinematics, elastic deformation of materials, buckling, and plastic flow. The materials needed for the experiments are all standard items which can be procured locally.

Twenty experiments are described in a booklet which forms the final report on this project. For each experiment the report contains a sample instruction sheet, which could be given to the student, and a list of the materials needed, which would be furnished to the student as a prepackaged kit. For some of the experiments there are actual test results for the information of the instructor.

Further information can be obtained from the project director.

233. Equipment for a New Strength of Materials Laboratory.

S. K. CLARK, Department of Engineering Mechanics, University of Michigan, Ann Arbor, Mich. 48104. (1963–1964)

This is a modification of a commercial hand-operated testing machine to make it suitable for torsion and tension tests. The equipment is relatively inexpensive, which makes it possible for the individual student to perform bench-scale experiments and develop his own ideas for extension of assigned work. The machine has a load capacity of 10,000 pounds.

Further information can be obtained from the project director.

234. Multi-Functional Machine for Materials Testing and Processing Experiments. NATHAN H. COOK, Department of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Mass. 02139. (1961–1962)

This device is a bench-size machine, instrumented to measure the forces involved in turning, milling, drilling, reaming, and tapping. It is also suitable for tension, torsion, and compression tests, combined tension-torsion tests, hardness tests, fatigue tests, wire drawing, punching, deep drawing, and bending. Materials tests can be carried out at temperatures to 1300°F.

A final report is available from the project director.

235. Theoretical and Applied Mechanics Curricula. HAROLD LIEBOWITZ, Graduate School, University of Colorado, Boulder, Colo. 80304. (Present address: Structural Mechanics Branch, Office of Naval Research, Washington, D.C. 20360.) (1961)

This study group met for a week to provide guides, detailed technical outlines, and abstracts of courses for improving solid mechanics curricula in a college engineering program. The study included a comprehensive examination of the requirements in applied mathematics, materials, continuous media, structures, environment, and reliability.

The lastest thinking and developments in solid mechanics were incorporated into undergraduate and graduate courses which were aimed at developing an integrated curriculum in solid mechanics with increased emphasis on solid-state physics, metallurgy, applied mathematics, and engineering science.

H. Liebowitz and J. M. Allen (eds.), *Curricula in Solid Mechanics*, Prentice-Hall, Inc. (1961)

H. Liebowitz and J. M. Allen, "Undergraduate and Graduate Curricula in Applied Mathematics, Materials, Structures, Environment, Reliability, and Continuum Mechanics," *Journal of Engineering Education* 54, 108 (1963).

236. Equipment for Teaching Dynamic Analysis. JOSEPH E. SHIGLEY, Department of Mechanical Engineering, The University of Michigan, Ann Arbor, Mich. 48104. (1962–1963)

A bench-type machine for demonstrating and teaching the meaning of dynamic unbalance in machinery and a bench-type cam and follower mechanism have been developed. The follower has both mass and elasticity so that at full operating speeds, the follower motion does not conform to the command machined into the cam. Both of these items of equipment are instrumented with appropriate, reasonably priced transducers so that such interesting quantities as displacement velocity, force, torque, etc., are displayed on an oscilloscope or fed into an electrical analog computer for various operations.

"The Mechanical Analysis Laboratory of the Department of Mechanical Engineering at the University of Michigan, Ann Arbor," by Herbert H. Alvord. This report describes comparable equipment and teaching procedures. It is not part of the present project, but can be obtained from the Department.

Further information can be obtained from the project director.

237. Multipurpose Tester for Demonstrations and Investigations of Shock and Vibration Phenomena. ALI SEIREG, Department of Theoretical and Applied Mechanics, Marquette University, Milwaukee, Wis. 53233. (1961–1962)

A portable two-mass system has been devised capable of illustrating most phenomena of shock and vibration, separately or combined. It also provides a versatile mechanical model for investigating these phenomena on different levels. The equipment can be briefly described as a two-mass system with leaf-spring suspension for the main and the secondary masses. Instrumentation for measuring strains, displacements, velocities, and acceleration is utilized.

A final report can be obtained from the project director. A sound film showing the capabilities of the tester is also available.

238. A Class Model Combined Geometric Analog Computer. PANAGIOTIS RAZELOS, Department of Mechanical Engineering, Columbia University, New York, N. Y. 10027. (1963)

A class model combined geometric analog computer has been developed which is used to demonstrate the use of the principle of analogy for obtaining approximate solutions of two- and three-dimensional steady state and transient heat conduction and other diffusional problems. The computer is a wooden tank filled with a solution of tetra-butyl ammonium picrate in the organic liquid Dowtherm A. External capacitance is introduced into the liquid in lumped form through contact terminals. The experimental performance of the computer for the three-dimensional case has been determined.

A final report is available from the project director.

239. Equipment for Obtaining Contours of a Fluid Membrane by Use of Monoscopic Photo-

grammetric Technique. ALPHIA E. KNAPP, Pan American Oil Co., Tulsa, Okla, and FRANK J. MCCORMICK, Department of Applied Mechanics, Kansas State University, Manhattan, Kans. 66504. (Grantee: Kansas State University.) (1961–1963)

At one end of an I-beam base, a membrane (soap film) is stretched over an opening in a template of sheet metal. The template is mounted in the vertical plane over a pressure chamber. Directly in front of, and parallel to, the template, a grid of parallel nylon filaments is placed. At the opposite end, and somewhat above the base, a concentrated light source is directed toward the template.

With the membrane elevated by a slight increase in pressure within the pressure chamber, the shadows of the nylon filaments on the membrane are photographed. From this photographic record, elevation contours of the membrane, then slopes and volumes, may be determined.

Details of construction and operation are available from the Kansas Engineering Experiment Station in Special Bulletin No. 41 listed below.

Frank J. McCormick and Alphia E. Knapp, "Design and Development of Laboratory Equipment for a Monoscopic Photogrammetric Method for Obtaining the Contours of a Fluid Membrane," Special Report No. 41, Kansas Engineering Experiment Station, Manhattan, Kans. (1963).

P. G. Kirmser and F. J. McCormick, "Edge Effects in the Membrane Analogy," *Experimental Mechanics* 5 (1) (1965).

240. An Educational Combustion-Reactor Design. C. R. GRAFLY DOUGHERTY, Department of Mechanical Engineering, Rutgers-the State University, New Brunswick, N. J. 08903. (1963–1964)

Design of a small, educational combustion-reactor suitable for undergraduate student operation has been completed. The equipment is capable of measuring heat release, blowout data, reaction rates, and efficiencies as a function of equivalence ratio and mass flow. Future work on this project will include the development of a number of projects suitable for use by the undergraduate engineering student. It will also include the design of a suitable temperature rake and a simple chromatography set up.

Further information can be obtained from the project director. A report will be available in the near future.

241. Transparent Overlay Visual Aids for Engineering Graphics. H. M. NEELY, Department of Mechanical Engineering, Kansas State University, Manhattan, Kans. 66504. (1959–1960)

Two series of transparent overlay visual aids were designed, developed, and used in engineering graphics at Kansas State University. The transparencies present basic principles of graphics rather than solutions to specific problems.

Copies of the final report are available from the project director.

Nuclear Engineering

For additional projects related to this section see also:

301. Atomic and Nuclear Experiments for Undergraduate Laboratories.

306. Use of Semiconductor Particle Detectors in Magnetic Deflection Beta Particle Spectrometers.

310. Versatile Nuclear Coincidence Apparatus for Undergraduate Use.

242. Pile Oscillator for University Nuclear Reactors. ALBERT L. BABB and WILLIAM E. WILSON, JR., Department of Nuclear Engineering, University of Washington, Seattle, Wash. 98105. (1961–1963)

The pile oscillator incorporates the following features that make it an excellent instrument for educational purposes: (1) simple construction, so that fabrication can be accomplished in an average college or university shop; (2) utilization of a neutron detection chamber in a conventional reactor instrumentation system; (3) use of commercial components wherever feasible; (4) simplified and graphic presentation of data employing a dual beam oscilloscope and low-frequency oscillator which will provide the student with a large amount of information—simply, rapidly, and directly; (5) remote pile oscillator frequency control; (6) simple operation and maintenance; and (7) versatility, so that the pile oscillator may be utilized with existing teaching reactors.

A final report can be obtained from the project directors.

G. Geography

243. Commission on College Geography. SAUL B. COHEN (Chairman), Graduate School of Geography, Clark University, Worcester, Mass. 01610; JOHN F. LOUNSBURY, Department of Geography, Eastern Michigan University, Ypsilanti, Mich. 48197. (Grantee· Association of American Geographers, Washington, D.C. 20036.) (1965–)

The Commission on College Geography is an outgrowth and continuation of the Geography in Liberal Education Project, which was supported by the National Science Foundation from July 1963 to March 1965. The Commission is conducting investigations on improving undergraduate education in geography and in interdisciplinary programs of study to which geography contributes.

The project maintains a coordinating committee at the national level to develop approaches to integrate geographic education within the broader educational context. The committee coordinates the efforts of institutions and individuals engaged in the development of experimental course programs, and acts, on request, as a consulting service to aid individuals or institutions in planning changes in geography curricula. This committee consists of ten geographers, one anthropologist, and one historian. Saul B. Cohen serves as chairman.

In addition to the coordinating committee, working panels of five to six members have been established. Each of these panels is devoting its efforts to specific problem areas in geographic education: the improvement of undergraduate teaching (developing resource letters, annotated lists of significant core materials, investigating the desirability of institutes, workshops and seminars for college teachers); interdisciplinary cooperation (exploring ways and means to improve communications among fields); the content and sequence of courses (investigating ways to improve subject content of courses and determining a basis for a rational sequence of courses in geography and related fields); and techniques and methods of presentation (investigating the possibilities of developing new and non-conventional instructional methods that might be adaptable to geography courses).

A 66-page published report, "Geography in Undergraduate Liberal Education" (1965) is available, without charge, from the Association of American Geographers. This report includes suggestions and guidelines for development of courses; five papers which explore various approaches to college level geography; and recommendations for future action. The recommendations in this report have resulted in the establishment of the Commission on College Geography.

Other materials which are being developed include an annotated list of core materials, an inventory and analysis of selected introductory courses, the development of introductory course outlines, and model undergraduate major and minor programs in geography.

H. Geology

For additional projects related to this section see also:

27. Oceanography—Eight Narrated Filmstrips.
28. Columbia-Lamont Marine Science Films.
164. Invisible Fixed and Fluidized Beds for Laboratory Demonstration and Study.

244. Council on Education in the Geological Sciences. William B. Hambleton (Chairman), Department of Geology, University of Kansas, Lawrence, Kans. 66045; John Harbaugh, Department of Geology, Stanford University, Stanford, Calif. 94305. (Grantee: American Geological Institute, 1444 N Street, N.W., Washington, D.C. 20006.) (1965–)

The Council on Education in the Geological Sciences maintains continuous inquiry into the state of geological education at the college and university level, and provides detailed recommendations and guidelines in problem areas. It encourages and assists development of appropriate new educational materials and activities. It reviews and evaluates current and projected programs in geologic education and provides for communication and essential consultation on educational improvement in the geological sciences.

CEGS developed as an outgrowth of the GEO-Study (Geological Education Orientation Study) program, an exploratory investigation of college and university geological education. The GEO-Study, sponsored by the American Geological Institute, examined in detail the status of geological education and made specific recommendations for improvement. Principal among these was the recommendation for the formation of the Council on Education in the Geological Sciences as an action agency to initiate and encourage fruitful devlopments in geological education.

The Council is aided by *ad-hoc* panels, and is currently active in five principal areas: (1) studies of sequence and content of courses leading to a major in geology, (2) studies of the relationship of geology to liberal arts education, (3) problems of interdisciplinary cooperation, (4) problems of secondary school earth science teacher preparation, and (5) study and implementation of methods of faculty improvement.

Current activities of the Council include: (1) development of recommendations for geology curricula, (2) design of an advisory program to aid colleges and universities in curriculum review and modification, (3) testing of four widely varied experimental courses in introductory geology, (4) development of mathematics curricula for geology majors, (5) preparation of an annotated bibliography on the application of mathematics to geology, (6) development of physics curricula for geology majors, (7) generation of "rescue" training programs for secondary school teachers of earth science, (8) design of college curricula for the preparation of secondary school teachers of earth science, (9) generation of experimental institutes and conferences for secondary school teachers of earth science, (10) preparation of an annotated bibliography of paperbound books of interest to teachers and students of geology, (11) enlistment of directors for summer institutes in areas of critical need for continuing education of college faculty, (12) exploration of possibilities of expanded faculty exchange programs, (13) generation of exploratory conferences to examine new areas of geological interest, (14) development of mechanisms for educational-industrial exchanges for faculty professional development, (15) generation of short papers on geological topics of current interest, and (16) the examination of possibilities for expansion of faculty fellowships.

The Council attempts to work through existing organizations and to involve the widest spectrum of the teaching faculty in the various projects. It is believed that by encouraging universal participation, the Council purpose can be most effectively accomplished.

For information on various publications related to college-level education in the geological sciences, write to the American Geological Institute.

245. Introductory Course in Historical Geology. Claude C. Albritton, Jr., Department of Geology and Geophysics, Southern Methodist University, Dallas, Tex. 75322. (1966–1967)

The project is developing a one-semester, introductory, historical geology course for prospective geologists and other students in which the approach is that of the history and philosophy of science. The course is being developed around four selected topics: the vast extension of the world in time, the incessant change in the configurational aspects of nature, extinction as a consequence of organic evolution, and the non-unique position of the primates in evolutionary history. In tracing the evolvement of these four important ideas, supporting evidence, logical structure, and relationship to contemporary thought will be critically examined. This course will follow, in conventional sequence, a one-semester course in physical geology. Emphasis in the new course is upon the method of inferring sequences from geological data and upon critical examination of principal concepts of historical geology.

The project will develop a wholly new lecture course, an annotated bibilography of primary and secondary sources, and lantern slides for lecture demonstrations.

Further information about the course will be available from the project director.

245A. Programed Geology Laboratory. Walter C. Sweet and Robert L. Bates, Geology Department, The Ohio State University, Columbus, Ohio 43210. (1966–1969)

The project is developing instructional films and a laboratory manual for a programed approach to the teaching of introductory college geology. The materials may also be useful at the secondary school level. Eight 5-minute instructional sound films on the following topics are planned: the physical properties of minerals, identification of igneous rocks, identification of sedimentary rocks, identification of metamorphic rocks, reading and interpretation of topographic maps, and identification and interpretation of fossils. The content of these films will be closely coordinated with the lecture syllabus and with the progamed laboratory manual, which is being prepared concurrently with the film scripts. Using the manual, the student will attempt to identify and interpret geological specimens and phenomena. The films are expected to be useful as adjuncts to a conventional introductory geology course, as well as in a programed laboratory situation.

Further information will be available from the project director.

246. High Pressure Triaxial Apparatus for Geology, Geophysics, and the Engineering Sciences. Fred A. Donath, Department of Geology, Columbia University, New York, N.Y. 10027. (1964–1966)

Equipment is being developed that will permit the study and demonstration of the behavior of materials subjected to differential stress under high confining pressure. The basic apparatus consists of a steel pressure vessel coupled by means of a collar to a 20-ton ram. Cylindrical test specimens, approximately one inch in length, are inserted in the pressure vessel and subjected to radial stresses up to 30,000 p.s.i. and axial stresses to 100,000 or 200,000 p.s.i. (depending on specimen diameter). Either compression or extension tests can be run.

Because of its compactness, the equipment can be mounted on a small stand and easily moved from one location to another; moreover, its simple design will permit operation by inexperienced personnel. Special tools and facilities are not required for maintenance.

A handbook now in preparation will describe in detail the design principles and operation of the apparatus, as well as instrumentation techniques and optional supplementary equipment for creep testing, pore pressure tests, and related experimental operations.

Further information can be obtained from the project director.

247. Ground Water Flow Models. *(Secondary, College, Graduate School).* JOHN W. HARSHBARGER, Department of Geology (Hydrology), University of Arizona, Tucson, Ariz. 85751. (1961–1963)

The ground-water flow models consist of consolidated porous and permeable media composed of size-graded quartz sand and epoxy resin simulating sedimentary rock, enclosed in a watertight plexiglass case. Basic geologic structures and lithologies are synthesized within the models. Water is introduced into the recharge end of the model, moves through the consolidated media, and is allowed to drain out at the discharge end. The hydraulic gradient across the models is adjusted by raising or lowering the point of drainage. Colored inks which are introduced into the flow system at points near the recharge end form visible flow lines, thus making it possible to study ground-water flow within the various geologic environments as simulated by the models. The porous media are permanently consolidated and should provide constant experimental results throughout the life of the models, estimated to be ten or more years.

The size of the models can be varied to suit the prevailing space requirements. The standard models range from 12 to 36 inches in height, 18 to 36 inches in length, and 1 to 4 inches thick. They can be constructed in the laboratory shop at a material cost of $25 to $75. The labor expenditure is about 5 to 8 man-days per model. The only facilities necessary for operation of the models are a source of water and a drain or container to catch the discharge water. Low capacity and inexpensive Roll-Flex type pumps may be used to recirculate or supply water if necessary. Filter pumps or simple siphons may be used to simulate discharging wells. The models can be set to operate semi-automatically as permanent laboratory displays or transported into the classroom for temporary use.

A final report can be obtained from the project director.

248. Transparent Three-Dimensional Hydraulic Flow Models. JOHN W. HARSHBARGER, Department of Geology (Hydrology), University of Arizona, Tucson, Ariz. 85751. (1963–1965)

The objective is to develop preliminary prototypes of transparent three-dimensional models consisting of clear plastic cases containing granular porous media immersed in clear liquid of the same refractive index as the media. Colored dyes inserted into the flow system of the model will form flow lines which will be visible in three dimensions. These flow lines can be observed and analyzed in order to understand more clearly the pattern of laminar ground-water flow as it is controlled by geologic factors and such manmade disturbances as wells.

249. Simple Optical Two-Circle Goniometer. W. D. JOHNS, Department of Earth Sciences, Washington University, St. Louis, Mo. 63130. (1963–1964)

An inexpensive, simple, optical, two-circle goniometer for crystallographic studies was designed, constructed and developed, and subsequently improved and modified through use in an undergraduate college course in crystallography. A prospectus was prepared describing the construction, operation, and use of the goniometer in conjunction with crystallographic measurement, stereographic projection, point group symmetry, and axial ratio (unit cell shape) determinations. Complete detailed working drawings are available for construction. These and the prospectus are available free of charge from the project director.

250. Photoelastic Equipment for Analysis of Structural and Engineering Geology Problems. E. G. BOMBOLAKIS, Department of Geology, Boston

College, Chestnut Hill, Mass. 02167. (1963–1964)

A loading-frame system has been designed and constructed for use with an economical, handmade, large-field polariscope for photoelastic stress analyses of two-dimensional models in structural and engineering geology. The system has been designed for load ranges up to 4,000 pounds biaxial compression with no significant buckling of the model. However, the system can be easily modified to perform bending and tensile tests, if so desired. Both the loading frame and the polariscope are designed exclusively of manufactured parts to enable construction by institutions in which machine-shop facilities are minimal or nonexistent. Only a small number of handtools are required to construct and assemble the loading frame and the polariscope.

Copies of the project report, "Construction of Photoelastic Equipment for Analysis of Structural and Engineering Geology Problems," are available from the project director.

I. Mathematics

For additional projects related to this section see also:

2. Minnesota School Mathematics and Science Teaching Project (MINNEMAST).
40. School Mathematics Study Group (SMSG).
44. Survey of Recent East European Literature in School and College Mathematics.
48. University of Illinois Arithmetic Project.
50. In-Service Films in Mathematics for Elementary School Teachers.
51. Foundations of Mathematics for Elementary Teachers.
52. UICSM: Films for Training Ninth-Grade Algebra Teachers.
53. Films for Mathematics Teachers.
55. Programed Correspondence Courses in Algebra and Geometry for In-Service Training of Secondary School Mathematics Teachers.
60. Inexpensive Digital Computers.
61. Formal Deductive and Symbolic Logic Teaching Equipment.
75. Coordinated Program for Mathematics and Physics Majors in Freshman and Sophomore Years.
177. Electronic Analog Teaching Aid for Mathematics, Science, and Engineering.
188. All-Solid-State Redesign of a Small Hybrid Analog/Digital Computer for Teaching Statistics and Random Processes.
193. Inexpensive Digital-to-Analog Converter for Curve Plotting with Small Digital Computers.
202. Automatic Plotting of Phase, Gain, and Root Locus from Pole-Zero Constellations.

251. Committee on the Undergraduate Program in Mathematics (CUPM). RICHARD D. ANDERSON (Chairman), Department of Mathematics, Louisiana State University; LINCOLN K. DURST (Executive Director), Committee on the Undergraduate Program in Mathematics, Box 1024, Berkeley, Calif. 94701. (Grantee: Mathematical Association of America, State University of New York at Buffalo.) (1960–)

The Committee on the Undergraduate Program in Mathematics is concerned with the system consisting of the undergraduate curriculum in mathematics, the students and their teachers, the purposes of the program, its achievements and shortcomings, and the facilities for undergraduate mathematics. The principal work is partitioned into four areas represented by panels. These are: (1) preservice training of elementary and secondary school teachers; (2) mathematics for students of engineering and the physical sciences; (3) mathematics for the biological, management, and social sciences; and (4) pregraduate education of potential research mathematicians. Detailed curricula and course syllabi have been designed for each of the above areas.

During 1964–65 a special subcommittee prepared a report describing a general curriculum in mathematics for colleges. The curriculum is economical enough to be taught by a small college staff, yet is designed to meet as many of the requirements of the separate panel recommendations as possible. A study has been made of undergraduate applied mathematics, as distinct from service courses for physical sciences, engineering, and computation. A basic library list for college libraries has heen developed by the advisory group on communications. A consultants bureau has been organized to offer advice and counsel to colleges and state organizations on curricular problems in mathematics and related matters. In addition, the Committee plans to direct a substantial amount of attention to the college mathematics teacher with the objective of improved recruitment and preservice training.

Additional information including recommendations and course guides may be obtained from the executive director.

252. Undergraduate Course in Mathematical Logic. Ainsley H. Diamond, Department of Mathematics, Stevens Institute of Technology, Hoboken, N. J. 07030. (1963–1964)

The purpose of the project is to develop an undergraduate course in mathematical logic which will introduce quantification theory and its role in other branches of mathematics. The distinctive feature of the course is the emphasis on the semantical aspects. The important semantical notions of model, satisfiability, and completeness are presented in such a way as to show how certain consequences of quantification theory are useful tools in other parts of mathematics, notably algebra. The connections between the semantical (interpretational, set theoretic) and syntactic (deductive) aspects of quantification theory are also established.

The basic concepts of model, satisfiability, etc., are first formulated in propositional logic using the truth-table method. The semantical theory is then obtained by analyzing sets of formulas by J. K. K. Hintikka's method of semantical tableaux. This analysis is then extended to quantification theory. A proof of the completeness theorem shows its relation to model theory. Rules of disproof of a set of formulas are expressed in terms of analysis, and the relation is established between these rules and the rules of proof in the familiar deductive systems of quantification theory. A discussion is given of formal systems of the sentential calculi for classical logic, intuitionist logic and Lewis' system of strict implication. An introduction to recursive function theory is based on the development in *Fonctions Recursives* of A. Grzegorczyk and Gauthier-Villars, Paris (1961). A brief discussion is given of Gödel's incompleteness theorems for arithmetic and the first-order predicate calculus. The notes are being revised and expanded and will be available in 1966.

253. Experimental Curriculum in Engineering Mathematics. R. C. Buck and John A. Nohel, Department of Mathematics, University of Wisconsin, Madison, Wis. 53706. (1962–1964)

The objective of this study is to improve instruction in engineering mathematics. This will be done by developing a number of courses in analysis and algebra along the lines suggested in the detailed recommendations of the Committee on the Undergraduate Program in Mathematics (CUPM). Specifically, this means a modification of the traditional calculus course to include, in the same amount of time, much of the basic material in differential equations and certain topics in numerical analysis related to the role of high-speed computers. These topics will not be introduced in isolation but rather as an integral part of the course, with the full attention to physical motivations where appropriate. In addition, materials will be developed for a one-semester course in linear algebra for sophomores and juniors in engineering.

A set of notes entitled "Beginning Analysis—Semester 3," by R. C. Buck, F. Brauer, and J. A. Nohel has been prepared and was used in class during the academic year 1964–65. These notes cover vectors in three dimensions, multiple integrals, functions of several variables, introduction to ordinary differential equations, infinite series, series of solutions of differential equations, and linear differential equations. Copies are available from the project directors.

254. Experimental Undergraduate Instruction in Computing. John G. Kemeny, Department of Mathematics, and Thomas E. Kurtz, Computation Center, Dartmouth College, Hanover, N. H. 03755. (1964–1966)

The Dartmouth Computation Center is being developed as a flexible teaching device for students in all fields. All students electing at least a year of freshman mathematics (over 70 percent of each class) are being taught the fundamentals of programing in the BASIC language and the use of the input-output stations to the Time-Sharing System. BASIC is an algebraic language that is simple and easy to teach, requiring typically only two or three hours of classroom time. The Time-Sharing System operates at least 8 hours per day, giving students the maximum opportunity to solve their problems at times convenient to them. The computer is already used extensively in courses in many departments including economics, geology, physics, chemistry, psychology, mathematics, and engineering science.

The project is producing several kinds of materials: (1) the user's manual for the BASIC language; (2) a description and block diagram of the principal components of the Time-Sharing System, particularly the BASIC compiler; (3) a number of short monographs containing illustrative computer problems to be used in connection with a variety of mathematics, physics, and engineering courses. All of these materials will be made available as soon as their final versions have been prepared.

255. Power Series and the Elementary Func-

tions. *(Secondary, College)* HOWARD LEVI, Department of Mathematics, Columbia University. (Present address: Department of Mathematics, Hunter College, 695 Park Avenue, New York, N.Y. 10021.) (1962)

A one-semester course in elementary functions based on the systematic use of power series was developed. The course is suitable for college freshmen and may serve as a terminal course in calculus. Topics include: (1) polynomials, including the division algorithm and infinite series as formal reciprocals of polynomials; (2) formal power series; (3) power series as functions; (4) functions in general, including continuity, the derivative, maxima and minima; (5) characterization of power series by means of functional equations; and, (6) Taylor's theorem and representability by power series.

A revised version of the experimental text is in preparation for publication by Addison-Wesley in 1966.

H. Levi, "An Experimental Course in Analysis for College Freshmen," *American Mathematical Monthly* 70, 877 (1963).

256. Introductory Course on Probability Matrices and Calculus for Students in the Biological and Social Sciences. *(Secondary, College)* G. BALEY PRICE, Department of Mathematics, The University of Kansas, Lawrence, Kans. 66045. (1962–1966)

The project is preparing two volumes of notes suitable for a two-semester course in probability, matrices, and calculus.

Volume 1 was completed and widely circulated by the Committee on the Undergraduate Program in Mathematics (see Item 251 in this book), but is now out of print. It contains chapters on systems of linear equations, matrices and algebraic systems, elementary set theory, counting problems, and probability. The book provides an introduction to modern computational procedures by treating algorithms and flow charts, especially those for the solution of systems of linear equations. It contains a number of applications to problems in accounting, business, economics, acceptance sampling, genetics, and sociology. It is suitable for use as a textbook for experimental classes and as a sourcebook.

Volume 2, on which work has begun, will contain an elementary treatment of differential and integral calculus in a setting of probability theory and applications to the biological, management, and social sciences. There will be chapters on differentiation, integration, logarithmic and exponential functions, and probability theory for nonfinite sample spaces. The calculus will be developed for relatively simple classes of functions so that emphasis can be placed on concepts and their applications rather than on complicated technique.

J. B. Johnston, G. B. Price, and F. S. Van Vleck, *Linear Equations and Matrices* (Addison-Wesley Publishing Co., 1966) makes use of some of the ideas developed in Volume 1 as described above.

Correspondence concerning the project should be addressed to the project director.

257. Course in Applications of Mathematics for Secondary School Teachers. GAIL S. YOUNG, Department of Mathematics, Tulane University, New Orleans, La. 70118. (1966–1968)

This project is preparing a sourcebook of materials for introducing present and prospective high school teachers to the applications of mathematics. The sourcebook will present a number of novel, contemporary applications of mathematics in all the many areas—such as physical science, engineering, business, social science, medicine, computing and linguistics—where it has become a tool. The applications will be presented at a mathematical level suitable for accompanying or following undergraduate courses in mathematics including analysis and abstract algebra. The format will be that of a one-semester course with sufficient material to allow considerable choice of topics according to the interests of class and teacher. The materials will be tried at several centers during the academic year 1966–67, and results of the trials will be made generally available along with the materials.

Further information will be available from the project director.

258. Honors Program for Mathematics Majors. FRANK T. BIRTEL, Department of Mathematics, Tulane University, New Orleans, La. 70118. (1964–1965)

The purpose of this project is to develop a two-semester (6 credit-hour) course in geometric analysis on manifolds based on recommendations of the Committee on the Undergraduate Program in Mathematics (CUPM) for pregraduate preparation of research mathematicians. CUPM recommendations in their present form are beyond the capacities of many institutions for the following reasons: (1) They represent ideal goals; (2) They lack sufficient details; (3) There are a great number of advanced undergraduate courses than can be realisitcally offered by most institutions. Occasionally, there are capable mathematicians at such institutions who could implement a realistic, detailed, and synthesized course in the spirit of these recommendations. The course should meet these general requirements: (1) be within the capabilties of honors juniors who have had the equivalent of Hille's *Analysis* (as freshmen) and Fleming's *Functions of Several Variables* (as sophomores)—actually, Crowell and Williamson's *Vector Calculus* on the sophomore level should be sufficient; (2) display the interplay and overlap of various fields; and (3) provide a source for concrete examples in depth of subjects the student will meet at the graduate level. In an attempt to meet these requirements and to avoid the disadvantages of the general CUPM recommended courses, topics were chosen as indicated from the following three CUPM outlines: (1) Outline II: Algebraic Topology (topics 1–7 and 24); (2) Outline II: Surface Theory (topics 1–3); and (3) Differential Geometry (topics 1–4).

Notes for this course are in preparation. These include tests, exercises, a critique on student performance, and a summary of the major pedagogical difficulties which were encountered. The course is being repeated again with the hope that resulting revisions will perfect the project. Experience indicates that the course can be effectively presented by any competent mathematician. No materials are available at the present time.

259. Experimental Program in Engineering Mathematics. R. J. WALKER, Department of Mathematics, Cornell University, Ithaca, N. Y. 14850. (1963–1965)

A course in mathematics to follow an eight semester-hour freshman course in differential and integral calculus will be developed for sophomore engineering students. The course will include many of the recommendations of the Committee on the Undergraduate Program in Mathematics; in particular: (1) computational techniques and numerical problems, both for hand computation and for coding and solution on an automatic digital computer; (2) concepts and techniques of linear algebra and matrix theory in the treatment of differential equations and vector calculus; (3) emphasis on the use of complex numbers; and (4) many applications of mathematics to problems of interest to engineers.

Writing and teaching will be done jointly by the department of mathematics and the college of engineering, and a close correlation will be maintained between this course and the courses in physics, mechanics, and electrical science taken concurrently by the students.

Text and problems for a six to eight semester-hour course have been prepared. Single copies are available from the project director.

260. Experimental Pregraduate Program in Mathematics. KENNETH O. MAY, Department of Mathematics, Carleton College. (Present address: Department of Mathematics, University of California, Berkeley, Calif. 94720.) (1961–1966)

The purpose of the project is to find more effective and economical methods of stimulating gifted undergraduates to do creative work in mathematics and of developing their skills in obtaining and presenting results. During the years 1956–61, the program for gifted students depended primarily on honors sections in the freshman and sophomore years and on activities centered around a colloquium for advanced students. The hypothesis now being tested is that the original objectives may be achieved without separate honors sections, by organizing non-credit colloquia at all levels, and making maximal use of a local journal for immediate publication of student work.

Delta-Epsilon, a journal for undergraduate research in mathematics, is published by the department for local circulation but will be sent free to individuals and libraries upon request. A report of the project will soon be available from the project director.

261. Automata and Nets. RAYMOND J. NELSON, Department of Mathematics, Case Institute of Technology, Cleveland, Ohio 44106. (1963–1965)

The aim of this project is to develop a complete set of notes and exercises for a course in automata. The course is at the advanced undergraduate level for mathematics students or the beginning graduate level for engineers having no background in modern mathematics. The course treats the theories of Kleene, Rabin and Scott, Moore, Chomsky, and others from a precise mathematical point of view, but with an eye on applications to logic design of computer nets and characterization of artificial languages and various problems associated with them. The notes also include discussion of the concepts of recursive functions and recursive solvability and unsolvability (from the point of view of Turing machines), with application to decision problems in analysis and synthesis of automata and the study of ambiguity in computer languages. Some attention is also given to the problems of logic design and minimization of combinational nets (O-state automata). Much of this material does not yet appear in any textbook, although the students are urged to consult S. Ginsburg, *Introduction to Mathematical Machine Theory* (Addison-Wesley Publishing Co.); A. Gill, *Introduction to the Theory of*

Finite State Machines (McGraw-Hill Book Co.); and E. F. Moore (ed.), *Sequential Machines: Selected Papers* (Addison-Wesley Publishing Co.).

Notes serving as text materials are being prepared for the course and will soon be available from the project director.

262. Computer Science Course and Curriculum Development. WILLIAM F. ATCHISON (Chairman), Curriculum Committee on Computer Science, Georgia Institute of Technology, Atlanta, Ga. 30332. (Grantee: Association for Computing Machinery, 211 East 43rd Street, New York, N. Y. 10017.) (1965–1966)

The Curriculum Committee on Computer Science (CCCS) of the Association for Computing Machinery (ACM) is primarily concerned with the development of a sound undergraduate and lower graduate computer science curriculum and the content of the associated courses. This is of particular concern for a newly emerging discipline such as computer science.

A series of about 16 courses is being developed in an extended outline form. A set of *Preliminary Recommendations for an Undergraduate Program in Computer Science* has been published in the September 1965 issue of *Communications of the ACM*. CCCS is currently revising these recommendations with the aid of consultants and welcomes suggestions. Reprints of these recommendations can be obtained by writing ACM at the above address. An earlier set of six suggested courses appeared in the April 1964 issue of *Communications of the ACM*.

Special attention is being given to courses in algorithmic languages and compliers, computer and programing systems, information structures, and related courses. These courses are central to the development of future computer scientists but are undergoing changes as the field develops. It is especially important here that course outlines be more complete and that they point to essential and lasting material. Consultants are being used to develop these courses further.

A revised curriculum and more complete course outlines are planned for publication late in 1966 or early in 1967. Intermediate reports on a limited basis will be available from the project director.

263. Computer-Based Instruction in Statistical Inference. HARRY F. SILBERMAN, System Development Corporation, 2500 Colorado Avenue, Santa Monica, Calif. 90406. (1965–1967)

This project involves an experimental program in computer-assisted instruction in statistical inference. Based on several years of developmental work by the grantee, and carried out in cooperation with the University of California at Los Angeles, the project includes the following: (1) a time-sharing system utilizing consoles located at the University of California at Los Angeles that will provide immediate simultaneous access to a Q32V computer; (2) a question-answering process which will permit users to query the machine in the natural language of the user; (3) on-line programing which will permit a student to write and check out computer programs by way of his teletype console; (4) a computer program for the teaching of statistics which will provide a sequenced set of problems, parameters for simulated populations and randomly sampled data, a library of statistical procedures, calculated statistical results, computational and other assistance, evaluation of student performance, feedback to the student, and a permanent record of student performance over the entire course; and (5) empirically developed instructional material utilizing the teacher, a textbook, and associated programed material. Instructors will be able to make successive experimental revisions of each small segment of material, developing progressively improved versions until the instructional objectives are achieved.

264. An Undergraduate Course in Affine, Projective and Metric Geometry Based on Linear Algebra. ROBERT J. TROYER, Department of Mathematics, University of North Carolina, Chapel Hill, N. C. 27514, and ERNST SNAPPER, Department of Mathematics and Astronomy, Dartmouth College. (Grantee: University of North Carolina.) (1965–1967)

The objective of this project is to develop classical geometry using linear algebra as the basic tool and thereby putting classical geometry into the modern undergraduate curriculum in a form usable by most branches of mathematics. The culmination of this project will be the development of a one-year course in affine, projective, and metric (both Euclidean and non-Euclidean) geometry.

A first draft of notes serving as text material is presently available on a limited basis. After experimentation and revision during 1966–67, final copies of the notes can be obtained by writing to Dr. Troyer, Department of Mathematics, University of North Carolina.

265. Preparation of Reports by the United States Commission on Mathematical Instruction. E. G. BEGLE, Cedar Hall, Stanford University, and LEON W. COHEN, Department of Mathematics, University of Maryland. (Grantee: Conference Board of the Mathematical Sciences, 1346 Connecticut Avenue, N.W., Washington, D.C. 20008.) . (1965–1966)

The purpose of this project is to prepare three special reports which the United States Commission on Mathematical Instruction (USCMI) has been asked to present to the 1966 meeting of the International Commission on Mathematical Instruction of the International Mathematical Union. Topics for the reports are: (a) special programs in mathematics for prospective physicists, (b) uses of the axiomatic method in secondary-school teaching, and (c) the role of problems in mathematics education. The reports will be prepared under the general supervision of USCMI and will be made available to educational institutions and interested individuals in the U. S. and abroad.

266. Experimental Teaching Program in Algebra. ROBERT J. WALKER, Department of Mathematics, Cornell University, Ithaca, N.Y. 14850. (1961–1964)

The objective is to develop curricula for three one-term courses called "Basic Concepts of Mathematics," "Linear Algebra," and "Algebra and Number Theory." The courses are designed primarily for future high school teachers, but are also suitable for others who do not wish or do not need a more theoretical survey of modern algebra. The first course (which is best taken first) treats set theory, axiomatic systems, the real number field and other simple algebraic structures, and cardinal numbers. It presupposes a year of calculus.

In general, a high degree of abstraction is maintained. There is no plan to compromise with the subject matter. For example, in "Linear Algebra" a linear transformation of one abstract vector space to another is defined first and then the matrix of a linear transformation relative to chosen bases in the vector spaces is discussed. The emphasis is, however, on the application of abstract theorems to concrete situations. Students are not expected to develop facility in proving abstract theorems, but they are expected to have a thorough grasp of the fundamental concepts of modern abstract algebra and their relevance for other fields of study.

Notes to serve as text material for the course have been written. Single copies are available from the project director.

267. Course in Mathematics for Prospective Junior High School Teachers. J. MAURICE KINGSTON, Department of Mathematics, University of Washington, Seattle, Wash. 98105. (1962–1963)

The course material includes a discussion of the manner in which the concepts of arithmetic are generalized in the study of algebra with emphasis on the basic pattern and structure of the number system of arithmetic and its expansion to the real number system. The fundamental ideas of Euclidean geometry are established in order to form a basis for an informal treatment by the teacher. Some elementary logic is presented along with an introduction to the language of sets, especially the way in which the latter facilitates the making of accurate and concise statements in algebra and geometry. Considerable attention is given to numbers in bases other than 10 and to the development of the standard topics of elementary algebra from factoring through the solution of elementary equations. The topics of measurement and approximation are included along with a brief introduction to elementary statistics.

The project director is planning a book for publication in the near future drawing on these materials.

For information on materials write to: Committee on the Undergraduate Program in Mathematics, P.O. Box 1024, Berkeley, Calif. 94701, or the project director.

268. Mathematics Courses for Prospective Elementary School Teachers. JOHN R. MAYOR and HELEN L. GARSTENS, Department of Mathematics, University of Maryland, College Park, Md. 20742. (1962–1965)

The purpose of this project was to prepare sample text materials in mathematics for preservice courses for elementary teachers. Two sequential semester courses have been prepared. Book I, the text for the first course, is concerned with the structure of the number systems of ordinary arithmetic and Book II is concerned with geometry, especially those concepts basic to the study of measurement. The two courses are intended to provide a sound mathematical foundation for teaching new as well as traditional approaches to mathematics in grades K through 6. Deductive procedures are stressed throughout the materials. The courses have been taught in about 100 sections at the University of Maryland, and in a number of other colleges. The preparation of the courses was a cooperative effort of the University of Maryland Mathematics Project, sponsored by the College of Education and the Department of Mathematics.

Mathematics for Elementary School Teachers, Book I, and *Mathematics for Elementary School Teachers, Book II*, may be purchased from the University of Maryland Mathematics Project, College of Education.

269. Geometry Course for Prospective High School Mathematics Teachers. SEYMOUR SCHUSTER, Minnesota School Mathematics and Science Center, University of Minnesota, Minneapolis, Minn. 55455. (1964–)

The principal objective is the preparation of a one-year college geometry course for the training of prospective high school teachers, with the intent of exploring various educational media and selecting those most appropriate for a given topic at each stage of the course. Portions of the course that most lend themselves to visual techniques will be prepared on film, using animation and special effects whenever appropriate. The major portion of text material will be produced in the form of detailed exposition and for programed instruction. The aim is to produce a course that does not require an instructor trained in geometry, and which needs only a minimum of administration by a faculty member.

The mathematical content will include the material recommended in *Course Guides for the Training of Teachers of Junior High and High School Mathematics*, published by the Committee on the Undergraduate Program in Mathematics of the Mathematical Association of America. Additional advanced topics, anticipating the needs of secondary teachers a decade hence, will include Euclidean geometry as a real inner-product vector space, convex figures, and differential geometry.

Units of text on foundations, elementary transformations, constructions and convexity, and related topics are available for small-scale testing.

270. Course in the Number System for Elementary School Teachers. RALPH CROUCH, Department of Mathematical Sciences, New Mexico State University, University Park, N. Mex. 88076, and GEORGE BALDWIN, Department of Mathematics, Eastern New Mexico University, Portales, N. Mex. 88130. (1962–1963)

An Intuitive Development of the Real Number System and Related Topics is a text for future elementary teachers designed to be used in two sequential, three semester-hour courses. The courses follow closely recommendations of the Committee on the Undergraduate Program in Mathematics of the Mathematical Association of America. They involve a study of the numbers used in elementary schools: whole numbers, common fractions, decimal fractions, and irrational numbers. Emphasis is on basic concepts and techniques: properties of addition, multiplication, inverses, systems of numerations, and the number line. Techniques for computation with numbers are derived from the properties and structure of the number system, and some attention is paid to approximation. Some elementary number theory, including prime number properties, even and odd numbers, and some arithmetic with congruences are included.

The revised text may be purchased from the Department of Mathematics, New Mexico State University.

271. Films and Other Teaching Materials for College Mathematics. CARL B. ALLENDOERFER (Director), Department of Mathematics, University of Washington; RICHARD LONG (Executive Director), Committee on Educational Media, Mathematical Association of America, P.O. Box 2310, San Francisco, Calif. 94126. (Grantee: Mathematical Association of America, State University of New York at Buffalo. (1963–)

The purpose of this project is to investigate the production, use, and evaluation of new media—films, television, programed learning, etc., in mathematical instruction at the college level. The project is operating in four divisions: (1) the preparation of supplementary films to assist in the teaching of a first course in the calculus; (2) a multi-media course on the number system for the preservice training of elementary school teachers, based on the recommendations of the Committee on the Undergraduate Program in Mathematics; (3) a series of filmed lectures by distinguished mathematicians; and (4) a study of programed instruction with production of some experimental programed materials to be used in connection with (1) and (2). The Committee is also engaged in a preliminary study on the use of television for the teaching of mathematics and in the evaluation of past experience in this field.

Materials produced to date in areas (1), (2), and (4) above are receiving field evaluation before general release. Single copies of *Programed Learning and Mathematical Education*, by Kenneth O. May, are available without charge from the executive director.

The following films (16mm, sound, black-and-white except as noted) are distributed by Modern Learning Aids:

Let Us Teach Guessing, demonstration by George Polya (color, 60 min.).

Mathematical Induction, lecture by Leon Henkin (color, 60 min.)

Mr. Simplex Saves the Aspidistra, with Frank Kocher, Leon Henkin, and Julius H. Hlavaty (color, 30 min.)

Theory of Limits (Part I–Limits of Sequences; Parts II and III—Limits of Functions and Limit Processes and The Cauchy Criterion for Convergence), lectures by E. J. McShane (34 and 38 min.)

Topology, with Raoul Bott and Marston Morse (30 min.)

Challenge in the Classroom: The Methods of R. L. Moore (color, 55 min.)

Challenging Conjectures, lectures by R. H. Bing (40 min.)

Differential Topology, three lectures by John Milnor (60 min. each)

Fixed Points, lecture by Solomon Lefschetz (color, 60 min.)

Göttingen and New York: Reflections on a Life in Mathematics, with Richard Courant (color, 43 min.)

The Kakeya Problem, lecture by A. S. Besicovitch (color, 60 min.)

Pits, Peaks, and Passes (Parts I and II), lecture on Critical Point Theory by Marston Morse (color, 48 and 26 min.)

Predicting at Random, lecture by David Blackwell (color, 43 min.)

The Search for Solid Ground, panel discussion with Mark Kac, John Kemeny, Harley Rogers and Raymond Smullyan (62 min.)

What Is an Integral? lecture by Edwin Hewitt (60 min.)

What Is Mathematics and How Do We Teach It? panel discussion with Lipman Bers, Samuel Eilenberg, Andrew Gleason, Henry Pollak, and Leo Zippin (60 min.)

Applications of Group Theory in Particle Physics, lecture by Freeman Dyson (60 min.)

Can You Hear the Shape of a Drum? lecture by Mark Kac (two versions: short version, color, 49 min.; long version, color, 67 min.)

The Classical Groups as a Source of Algebraic Problems, lecture by Charles Curtis (65 min.)

Additional titles are being added to this series; information can be obtained from Modern Learning Aids.

272. Teaching Aid for Analog Computer Instruction.

KARL KAMMERMEYER and JAMES O. OSBURN, Department of Chemical Engineering, State University of Iowa, Iowa City, Iowa 52240. (1959–1960)

The teaching aid is a plugboard similar in appearance to the board of a Heathkit analog computer, but containing only four amplifiers. The plugboard is connected to the amplifiers on the computer by plugs and jacks. In an analog computer laboratory each student gets a plugboard and a collection of resistors, capacitors, and connectors. He then proceeds to build his program independently of the computer. When this has been finished correctly, the board is plugged into the computer and the solution is obtained in a short time. In this way, the use of the computer and the time of the instructor are extended. The plugboards are built from standard electronics parts at a cost of about $20, plus 15 hours of construction time. The extensive use of the board in computer laboratory instruction during the last two years has shown that it is a versatile and eminently practical accessory.

James O. Osburn, "Analog Computer Instruction. A Plugboard Teaching Aid," *Journal of Chemical Education* 38, 492 (1961).

273. Devices for Sampling Statistics.

ROBERT W. HEATH, Department of Systems Engineering, University of Arizona. (Present address: Educational Testing Service, Western Office, 1947 Center Street, Berkeley, Cailf. 94704.) (1960)

Two devices have been developed that sample from an arbitrary population distribution and present the observation to the operator. The electromechanical device developed under the present project employs a motor-driven arm that rotates a sensing unit over a circular pattern of contacts divided into sectors, the length of each sector being proportional to the area under the normal curve. When the arm stops, the observation is presented to the operator by an indicator light representing one of thirteen score values. The electronic unit uses an oscillator to drive counting tubes that are gated by means of selector switches. Through these switches, any shape of distribution can be set in the device. When the operator takes a reading, the counting is interrupted, and the observation is presented to the operator by a Nixie read-out tube. The parts for the electromechanical device cost less than $100 and the components for the electronic apparatus were purchased for about $350. The electromechanical device could be assembled in any workshop; the electronic sampling unit requires more work but could be constructed by an electronics technician.

Further information concerning construction details and wiring diagrams can be obtained from Albert E. Bartz, Department of Psychology, Concordia College, Moorhead, Minn. 56560.

J. Meteorology

For additional projects related to this section see also:

22. Motion Pictures, Filmstrips, and Slides in Meteorology.

24. Manual of Lecture Demonstrations, Laboratory Experiments, and Observational Equipment for Elementary Meteorology.

28. Columbia-Lamont Marine Science Films.

274. Computer Applications in the Atmospheric Sciences. E. WENDELL HEWSON, Department of Meteorology and Oceanography, University of Michigan, Ann Arbor, Mich. 48104. (1962–1965)

The objective of the grant, to "... develop the subject matter and the techniques for the application of electronic computers to typical problems that arise in the atmospheric sciences into an advanced course of instruction for graduate students . . ." has been largely accomplished. The substance of the resulting course has been assembled into a course manual. Copies of this manual will be distributed to interested professors and departments of meteorology and applied mathematics mainly in the United States.

Interested teachers of meteorology and applied mathematics may request copies of the manual from the above-named department. Such requests will be filled until the supply is exhausted

275. Laboratory and Demonstration Equipment for Meteorology. *(Secondary, College)* FRANK R. BELLAIRE, Department of Meteorology and Oceanography, University of Michigan. (Present address: Great Lakes Research Division, Institute of Science and Technology, University of Michigan, Ann Arbor, Mich. 48104.) (1961–1962)

Apparatus has been constructed for demonstrating: (1) the radiation characteristics of the atmosphere by utilizing and combining the radiation experiments of physics; (2) the characteristics of atmospheric vortices on various scales; (3) the hemispherical flow of the atmosphere; (4) atmospheric flow with Schlieren or shadow techniques.

K. Physics

For additional projects related to this section see also:

62. Physical Science Study Committee (PSSC).

63. Physical Science Study Committee—Advanced Topics.

64. Harvard Project Physics.

65. Engineering Concepts Curriculum Project.

73. Introductory Course in Chemistry and Physics.

75. Coordinated Program for Mathematics and Physics Majors in Freshman and Sophomore Years.

79. Overhead Projection Series of Lecture Experiments in the Sciences.

137. Models of Crystallographic Space Groups.

138. Three-Dimensional Models in Phase Rule Studies.

139. New Atomic, Molecular, and Crystal Models.

142. Nuclear Magnetic Resonance Spectrometer.

144. Equipment for Demonstrating Magnetic Susceptibility and Absorption Emission Spectra.

195. Equipment and Experiments for a Semiconductor Device Laboratory.

199. Lecture Demonstration Equipment for Courses in Electromagnetic Fields and Waves.

200. Electromechanical Forces and Magnetic Circuits.

214. Demonstration-Experiment Films in Fluid Mechanics.

225. Experiments on Coupled Flows in Solid-State Devices.

242. Pile Oscillator for University Nuclear Reactors.

249. Simple Optical Two-Circle Goniometer.

276. Commission on College Physics (CCP). E. LEONARD JOSSEM (Chairman), Ohio State University, Columbus, Ohio 43210; JOHN M. FOWLER (Executive Secretary), Commission on College Physics, Physics and Astronomy Building, University of Michigan, Ann Arbor, Mich. 48104. (Grantees: Bryn Mawr College, 1959–1964; University of Michigan, 1964– .) (1959–)

The Commission on College Physics, an independent group of 20 physicists, was established by the American Association of Physics Teachers for the improvement of undergraduate instruction in physics. Recognizing that this improvement can be made only by physics departments and physics teachers, the Commission considers that the major action toward its objectives should be taken by universities, colleges, and professional physics organizations. In its major function as a "nerve center" for curriculum development, it collects information about physics teaching and experiments for its improvement; distributes this information to those whose activities may be affected by it; encourages new developments in course content, laboratory practice, laboratory apparatus, teaching aids, etc., and helps institutions to organize institutes and conferences for the college physics teachers. The Commission initiates action where developments appear desirable but are not under way in individual institutions, or where action on a national scale appears necessary.

Examples of recent and current activities of the Commission are:

1. Conferences: A national conference on New Materials for Introductory Physics Courses was held in May 1965. The Conference, arranged in cooperation with the Department of Physics of the University of Minnesota, considered a variety of materials (texts, lecture demonstrations, laboratory experiments, and films) recently produced or in process of production. Specifically intended for physics and engineering majors, these materials differ from most of those previously available in that they characteristically emphasize fundamental concepts which form the foundations of contemporary physics, lay stress on understanding the subject matter in terms of physical concepts as well as mathematical analysis, and make strong ties to observable physical phenomena. An account of this Conference appeared in the Commission *Newsletter* No. 8 (July 1965).

2. Exploration of new modes of undergraduate physics instruction: Through its Panel on New Instructional Materials, the Commission encourages work on materials at all undergraduate levels, intended to reach a broad spectrum of students. A small group at Aspen, Colorado, during the summer of 1964, laid the groundwork for a two-month working conference at Seattle during the summer of 1965 under a grant to the University of Washington. It is anticipated that efforts in this area will be continued by individuals and small groups in many parts of the country.

3. Regional Conferences: The Commission assists individual institutions in planning short regional conferences intended to help the college teachers keep abreast of current teaching materials and techniques.

4. Stimulation of work on new physics films for college use, e.g., films illustrating the role of symmetry principles in the formulation of physical laws.

5. Preparation and publication of a series of paperback books (Momentum Books, published by D. Van Nostrand Co., Inc.) suitable for supplementary reading by college physics students. This operates as a self-sustaining activity, without support from grant funds.

6. Publication of a *Newsletter* to keep the profession informed of new developments.

Descriptions of the Commission's activities are available in the following: (1) "Progress Report of the Commission on College Physics," *American Journal of Physics* 32, 398 (1964); (2) "Progress Report of the Commission on College Physics," *Ibid.* 30, 665 (1962); (3) "Review Conference of the Commission on College Phiysics," *Ibid.* 31, 98 (1963); and (4) "Recommendations of the Second Ann Arbor Conference on Undergraduate Curricula for Physics Majors," *Ibid.* 31, 328 (1963).

Requests to receive reprints, the *Newsletter*, or other publications should be addressed to the executive secretary.

277. Berkeley Physics Course and Laboratory.

E. M. PURCELL, Department of Physics, Harvard University, Cambridge, Mass. 02138; A. C. HELMHOLZ, Department of Physics, University of California, Berkeley, Calif. 94720. (Former director: CHARLES KITTEL, University of California, Berkeley.) (Grantee: Educational Services Incorporated, 55 Chapel Street, Newton, Mass. 02158. (1962–)

This is a two-year, elementary college physics course for students majoring in science and engineering. The intention is to present elementary physics, as far as possible, in the way in which it is used by physicists working in the forefront of their field. This principle determines very largely the spirit in which the subjects are developed. The group has sought to make a course which would strongly reflect the revolution of physics of the last hundred years.

The course breaks with the traditional assumption that the student has learned nothing about physics in high school. Concurrent enrollment in a mathematics course that includes calculus is assumed. Titles and authors of the five parts are: *Mechanics* (C. Kittel, W. Knight, and M. Ruderman), *Electricity and Magnetism* (E. M. Purcell), *Waves* (F. Crawford), *Statistical Physics* (F. Reif), and *Quantum Physics* (E. Wichmann). The first two volumes have been published; preliminary editions of *Waves* and

Statistical Physics, and a second draft of *Quantum Physics* are in school trial.

A new laboratory to accompany the course has been developed under the direction of A. M. Portis. The laboratory is built from nine groups of four experiments each. These groups deal with: (1) electron dynamics, (2) linear elements, (3) nonlinear elements, (4) amplifications, (5) signal propagation, (6) wave propagation in space, (7) electron counting, (8) photon physics, and finally (9) a project laboratory in atomic physics.

Although the laboratory experiments emphasize electron physics, extensive analogies are made to other branches of physics and many laboratory demonstrations are suggested. The laboratory has been successfully used with other than the Berkeley texts, intermixed with some of the more traditional experiments, and as an intermediate laboratory taken by majors in their junior year. It is published in three separately bound manuals by the McGraw-Hill Book Company. Equipment suitable for performing the first eight groups of laboratory experiments is available from the Heath Company, Benton Harbor, Michigan, and from Hickok Teaching Systems, Cambridge, Massachusetts.

Preliminary editions of *Waves* and *Statistical Physics* and further information are available from the project directors.

278. Science Teaching Center: College Science.

Robert I. Hulsizer, Science Teaching Center, Massachusetts Institute of Technology, Cambridge, Mass. 02139. (1961–)

The Science Teaching Center concerned itself from 1961–1964 with the development of apparatus, films, text material, and resource papers for college physics courses. Recently, 1963–1965, the major effort has been to produce text material for an introductory physics course for scientists and engineers. This material will be published in several small volumes starting in 1966. In preliminary form it has been taught at MIT and at several cooperating institutions. Laboratory apparatus has been developed for experiments in optics, pressure of light, angular momentum of circularly polarized microwaves, polarization states of photons, Franck-Hertz effect, viscosity of gases, temperature variation of Gamma for gases, specific heat of gases, thermal conductivity of gases, damped forced simple harmonic oscillations, and field emission of electrons. Some of these have been filmed as demonstrations. Corridor experiments have been developed in a number of topics; some of these have been filmed.

Original papers on definitive experiments or theories in physics have been extracted for reprinting and in some cases written up as part of review papers or books with supplementary material to aid comprehension by students. This general program in physics will continue with emphasis on more corridor demonstrations and experiments and on aid in the development of a project laboratory for sophomores.

Work is starting on the development of project laboratories in cellular biology and neurophysiology. These involve training students in the techniques and experiments of contemporary biological research. Also, a program is underway using a computer and associated cathode-ray-tube displays to represent the structure of protein molecules, to display various possible configurations, and to compute the energy of these configurations. The same computer and display will be used to enable students in all fields to work out and graph solutions to various problems.

Work started also in the summer of 1965 to develop new laboratory experiments in general, physical, and organic chemistry.

Most of the apparatus developments have been described in papers published in the *American Journal of Physics*, beginning in 1963. A preliminary version of the text for an introductory course in physics, *Physics, A New Introductory Course*, is available upon request. All of the films have been produced in collaboration with the NSF-supported project on "Films for College and University Physics Courses" (see Item 289). The optics kit and the mechanical resonance apparatus are marketed commercially by Macalaster Scientific Corporation.

Current progress reports and reprints of articles may be obtained by writing to the center.

279. Materials for Undergraduate Curricula in Physics.

E. M. Henley, Department of Physics, University of Washington, Seattle, Wash. 98105. (1965–1966)

This project drew together about 40 physicists and a dozen film-makers and designers for a 9-week writing session in the summer of 1965. Their goal was to begin to create new materials for physics instruction, materials specifically designed to reach a much broader audience of college students than that presently enrolled in physics. The core of the project was the writing of a number of monographs. Each monograph is composed of two to four major sections of different levels of sophistication. The aim was to provide teachers with flexible materials in a wide variety of styles which they might then be able to use as the basis for new kinds of courses. Work was initiated on some 20 monographs in the areas of forces and fields, quantum mechanics, thermal and statistical physics, and the structure and properties of matter. Those in advanced stages are being made available on a limited basis for review and classroom testing.

Some members of the project worked on new apparatus, e.g., an air-supported chain of masses for studying wave motion. Three sequences of experiments were built up as integral parts of a related set of physical ideas. A significant effort was devoted to the preparation of scripts and storyboards for films; some footage on experimental sequences was shot and a small anthology of visual techniques was made. Several 2-minute segments of film—animated line drawings—were made using a computer in combination with a graphic display unit to draw the frames.

By way of exploring what can be done to provide more assistance to the faltering student, several short instructional sequences were written whose presentation to the student is computer controlled. The student responds freely through a typewriter keyboard; the computer compares his answer to a stored bank of responses; a match determines the next presentation, either through a keyboard or by slide. One such sequence, on geometrical optics, was developed to the point of classroom trial.

Some progress was made in the use of design analysis to assist the planning and creation of new instructional materials. For one week a small task force of physicists and designers explored the ideas of elementary kinematics. They strove to identify the basic ideas and the most effective modes for presenting each.

280. Center for Educational Apparatus in Physics.

Fritjof E. Christensen, American Institute of Physics, 335 East 45th Street, New York, N.Y. 10017. (Present address: St. Olaf College, Northfield, Minn. 55057.) (1963–1965)

The project, which is cosponsored by the American Association of Physics Teachers (AAPT), is directed toward the problems of developing and making available better physics apparatus for instructional purposes. The AAPT Committee on Apparatus for Educational Institutions serves as the advisory committee for the project.

The Center's information service invites inquiries concerning sources of supply for educational materials and equipment in physics. In addition, the Center is in touch with those physicists—both academic and industrial—who are or would like to be active in the design and planning of such equipment. Conferences are arranged to encourage the development of new apparatus. Manufacturers of educational equipment are apprised of new developments through a biennial apparatus competition, surveys of apparatus needs, meetings, and a newsletter. Visits to academic and industrial laboratories yield information about the development of the new physics apparatus. To promote a wider exchange of ideas and developments concerning apparatus for physics teaching, the Center assists in the preparation of the apparatus notes appearing in the *American Journal of Physics.*

The apparatus development program of the Center has included a conference on nuclear counters in teaching and one on lasers, both held at Columbia University. Reports on the conferences are in preparation. Apparatus design and development received considerable impetus in the AAPT Apparatus Competition of 1965. Under auspices of the Center, visits were made by physicists to college and university teaching laboratories, in particular those of small or intermediate size, to consult with the teaching staff concerning ways of strengthening laboratory programs.

Reports on various activities of the Center have been made available to educational institutions or are about to be published in the *American Journal of Physics. Novel Experiments in Physics,* a reprint volume of laboratory notes of 80 selected experiments, was published in June 1964. The report, *Survey of Teaching Apparatus in Physics, 1965,* was released in March 1965, and distributed to manufacturers of educational apparatus and academic institutions. During the summer of 1964, a survey of experiments on the Mössbauer Effect, which involved both industrial and academic laboratories, was conducted; a report will appear in the *American Journal of Physics.*

Two bibliographies dealing with apparatus for physics teaching have been prepared. One of them—"Physics Apparatus, Experiments, and Demonstrations"—is now available.

Requests for copies of publications and for information concerning apparatus should be directed to the Center.

281. Apparatus Drawings Project.

W. C. Kelly and R. G. Marcley, American Institute of Physics and American Association of Physics Teachers, 335 East

45th Street, New York, N.Y. 10017. (Dr. Kelly's present address: National Academy of Sciences-National Research Council, 2101 Constitution Avenue, N..W., Washington, D.C. 20418; Dr. Marcley's present address: California Institute of Technology.) (1959–1960)

The AIP-AAPT Apparatus Drawings Project has prepared complete shop drawings of 30 pieces of apparatus for laboratory work and lecture demonstrations in college physics. Approximately 25 colleges and universities were visited, and notes and sketches of apparatus were collected. The shop drawings were prepared by professional draftsmen. The drawings and notes have been published in slightly abbreviated form in the *American Journal of Physics* and separately as a portfolio and bound volume of complete full-scale drawings. The drawings and notes enable physics departments to decide whether apparatus developed elsewhere would be useful in their teaching and, if so, to provide their shops with adequate information for constructing the apparatus. Care has been taken in the notes to describe special techniques so that students can help in making the equipment. Kits of parts for constructing many of these pieces of equipment are available commercially.

The 30 pieces of apparatus described in the series include: a Balmer series spectrum tube, apparatus for the magnetic field of a circular coil, air suspension gyroscope, resolution of forces apparatus, mass spectrometers, Bragg diffraction apparatus, linear oscillator, simple kinetic theory demonstration, air suspended pucks for momentum experiments, Classen's method for e/m of electrons, Hall effect magnet, large electromagnet, omegatron for determination of e/m of the proton, acceleration carts and track, nuclear magnetic resonance by absorption technique, Rutherford scattering of alpha particles by thin metal foils, electron paramagnetic resonance, small X-ray tube ionization source for Millikan oil drop experiment, versatile electric timer control system, ionization chamber, proportional counter, impulse driven torsional mechanical oscillator, platinum-wedge black body, whirligig, a conical pendulum for centripetal force experiments, vertical-circle apparatus, apparatus for investigating the properties of sound waves, versatile X-Y projector plotter, accessory apparatus for large electromagnet, and atomic beam apparatus for mean free path.

W. C. Kelly, "Introduction to Apparatus Drawings," *American Journal of Physics* 28, 33 (1960), and subsequent articles in this journal.

Survey of Teaching Apparatus in Physics, W. C. Kelly (ed.), American Institute of Physics and American Association of Physics Teachers, 1961.

AIP Educational Newsletter (February 28, 1962).

Information on the Apparatus Drawings Project may be obtained from the American Institute of Physics. The portfolio and bound book of 30 sets of drawings and notes are available from Plenum Press, Inc.

282. Preparation of Resource Letters in Physics.

ARNOLD B. ARONS, Department of Physics, Amherst College. (Grantee: American Association of Physics Teachers, 335 East 45th Street, New York, N.Y. 10017.) (1962–1964)

These letters constitute an effort to improve course content by giving the college or university teacher ready access to basic literature of a field by: (1) guiding them into the literature of both old and new areas of subject matter with which they may be unfamiliar, but which they would like to work into new or existing courses; (2) indicating published material which might be useful to students in course work or in special projects; (3) giving references to available films, demonstrations, and laboratory equipment in a given subject area; and (4) calling attention to historical and philosophical material that might be useful in extending the intellectual content of technical courses.

A resource letter is not meant to be a definitive or exhaustive bibliography, but rather an annotated guide that leads an individual into the field through the best starting points to the more advanced levels. The difficulty of referenced material is evaluated as elementary, intermediate, or advanced. Certain references are starred to indicate that they are particularly important and fundamental to penetration into the subject matter. From among the starred references in the resource letter, about 100 pages of material are selected comprising important items scattered in journals and not available in textbooks; these items are then reprinted in a booklet that is offered for sale by the American Institute of Physics. (The reprint booklet part of this project is supported by the American Association of Physics Teachers.)

Resource letters on the following subjects have been issued to date: *Polarized Light; Plasma Physics; Special Relativity; Mössbauer Effect; Kinematics and Dynamics of Satellite Orbits; Quantum and Statistical Aspects of Light; Evolution of the Electromagnetic Field Concept; Friction; Superconductivity; Semi-*

conductors; Nuclear Structure; Evolution of the Energy Concept; Philosophical Foundations of Mechanics; Nuclear Magnetic Resonance; Masers and Optical Pumping; Molecular Beams; Science and Literature; and *Achievement Testing.*

Copies of resource letters may be obtained by sending a request with a self-addressed, stamped envelope to the American Institute of Physics.

283. Current Presentation of Physics to Nonscience Majors. Malcolm Correll, Department of Physics, University of Colorado, Boulder, Colo. 80304. (1964)

This conference, held in July 1964, assembled 30 physicists and 10 people from related disciplines, the social sciences, and the humanities. Participants were selected for their interest in teaching science to those students who will not enter the scientific disciplines in a professional way. The conference began by looking at several notable efforts to teach physics to the nonscientist and centered its continuing discussion around the development of programs to improve such courses throughout the country.

The 200-page paperbound *Proceedings of the Boulder Conference on Physics for the Nonscience Major* has been published and is now available; single copies may be requested from the conference director or from the Commission on College Physics, Physics and Astronomy Building, University of Michigan, Ann Arbor, Mich. 48104. The report includes several suggestions for future projects which should aid in defining appropriate goals for physics instruction to nonscience majors. Also, it should stimulate experimentation in the design of new approaches which are as rigorous, yet not necessarily as mathematical, as introductory courses for science majors.

284. Summer Workshop in Introductory College Physics. Robert Resnick and Harry F. Meiners, Department of Physics, Rensselaer Polytechnic Institute, Troy, N.Y. 12181. (1960–1961)

Demonstration and laboratory apparatus for the introductory college physics course was developed during a summer workshop. A report containing descriptions of 48 completed projects was prepared and distributed to 600 interested individuals and institutions. The report contains a detailed drawing and a materials list for each piece of equipment, as well as directions for use and other pertinent comments. Projects include ion motor, driven linear oscillator, stroboscopic techniques, fluorescent optical models, hysteresis demonstrator, discharge tube, photoelectric trigger, measurement of Hall coefficient, harmonic analyzer, plastic solid-CO_2 pucks, Bragg reflection with ripples, two-dimensional kinetic theory model, X-Y plotter, and orbital motion.

The 185-page volume, *Demonstration and Laboratory Apparatus Report of the 1960 Summer Visiting Professor Workshop,* may be purchased from the Rensselaer Union Book Store, Rensselaer Polytechnic Institute.

285. Summer Conference on the Teaching of Physics in the Two-Year Institutions of the State University of New York. Clifford E. Swartz, Department of Physics, State University of New York at Stony Brook, Stony Brook, N.Y. 11790. (1965–)

A four-week conference was conducted at the State University of New York (SUNY), Stony Brook, during the summer of 1965. The conference staff was drawn from the physics faculty at SUNY, Stony Brook, who had been active in curriculum revision programs. Participants included one leading staff member of each two-year unit of the SUNY system. The first one-third of the conference was devoted to a survey of recent developments in the teaching of introductory physics and the problems of adapting new materials for use in the two-year college. The remaining two-thirds of the conference time was devoted to detailed consideration of an elementary presentation of the special theory of relativity. Problem analysis, laboratory work, film review, and study of monographs were all aimed at preparing suitable materials for guidance of teachers in two-year institutions. The results of the conference were applied during the 1965–66 school year with evaluative sessions planned for the annual meetings of the two-year college faculties.

286. Source Materials for the History of Recent Physics in the United States. Charles Weiner, American Institute of Physics, 335 East 45th Street, New York, N.Y. 10017. (1963–1965)

The major activities of this project are: (1) locating items (manuscripts and apparatus) of potential significance for studying the development of physics, and of the physics community, in the United States from 1890 to the present; (2) urging scientists, industrial and academic institutions, libraries, science museums, and others to preserve documents recording the history of physics in the United States and to catalogue such materials; the project assists such work wherever possible; (3) recording interviews with physicists associated with significant discoveries made in the United States, and obtaining a photographic or other record of apparatus used in important researches; (4) gathering and organizing a biographical-bibliographical collection of material on some 1200 present and past members of the physics community in the United States; (5) organizing the information and some archival material, gathered according to the preceding four objectives, into an archives located at the American Institute of Physics.

A *Newsletter* describing the Project on the History of Recent Physics in the United States, is available from the American Institute of Physics.

287. Apparatus for College Physics. WALTER EPPENSTEIN and ROBERT RESNICK, Department of Physics, Rensselaer Polytechnic Institute, Troy, N.Y. 12181. (1963–1965)

Laboratory and lecture demonstration apparatus to meet known national needs in college physics courses have been planned, designed, and constructed. Following a spring conference, five visiting physicists worked directly with six physicists from the Rensselaer faculty and a supporting technical staff during a two-month period in the summer of 1964. About 20 projects started by the group during the summer have been completed at Rensselaer and other institutions, and the resulting apparatus is being tested in classes. A final report will include photographs and design drawings of all apparatus, discussions of classroom use and operating procedures for experiments and demonstrations.

Nine papers on the Workshop Project were presented at the meeting of the American Association of Physics Teachers at the University of Tennessee in June 1965. Abstracts of these papers are being published in the *American Journal of Physics.* A limited number of Workshop Reports are available from the project director.

288. Films for College and University Physics Courses. JERROLD R. ZACHARIAS and JAMES S. STRICKLAND, Educational Services Incorporated, 55 Chapel Street, Newton, Mass. 02158. (1961–)

This program is a means to provide many of the new demonstrations and laboratory experiments which are most appropriately presented via films for the new college and university physics courses (such as the Berkeley Physics Course, the Feynman Lectures, PSSC Advanced Topics Program, the Science Teaching Center program of the Massachusetts Institute of Technology, and the curriculum studies of the Commission on College Physics). Such material as film notes, journal articles, data, photographs, and slides are also provided where appropriate.

Eleven lecture-demonstration films from 8 to 38 minutes in length and a series of 23 short, silent films have been produced. Films presently in production include: velocity distribution of atoms in a gas; mass and energy conservation in positron-electron annihilation; polarization of photons—viewed via quantum mechanics; the Stern-Gerlach experiment; Brownian motion, the random walk; the angular momentum of radiation; soap film oscillation; and the measurement of the atomic mass of polonium and helium. Some new work has begun on several short, silent, computer-generated films concerned with the presentation of basic ideas and concepts in statistics and quantum physics.

The 16mm, black-and-white, sound films listed below are available for review or trial use without charge. They may also be purchased. Until arrangements are made for commercial distribution, inquiries should be directed to: Film Librarian, Educational Services Incorporated.

The Size of Atoms from an Atomic Beam Experiment, John G. King (28 min.); *Angular Momentum, a Vector Quantity,* Aaron Lemonick (27 min.); *The Ultimate Speed, an Exploration with High Energy Electrons,* William Bertozzi (38 min.); *Time Dilation, an Experiment with μ-Mesons,* David H. Frisch (36 min.); *Momentum of Electrons* (color), John G. King (10 min.); *Reflection and Refraction, Wave Phenomena I,* James Strickland (17 min.); *Interference and Diffraction, Wave Phenomena II,* James Strickland (19 min.); *Barrier Penetration, Wave Phenomena III,* James Strickland (8 min.); *Bragg Reflection, Wave Phenomena IV,* James Strickland (10 min.); *Doppler Effect, Wave Phenomena V,* James Strickland (8 min.); and *Solder Glass Technique,* John G. King and Jan Orsula (20 min.); *Field Emission of Electrons,* A. P. French (4 min.); *Photo Emission of Electrons,* A. P. French (4 min.); and *Thermionic Emission of Electrons,* A. P. French (6 min.).

The following short silent film demonstrations are available from commercial distributors. Running times vary from 2 to 4 minutes: (a) Coupled Oscillator Series (color): *Energy Transfer, Other Oscillators,* and *Normal Modes;* (b) Ripple Tank Wave Phenomena Series (black-and-white): *Reflection of Straight Waves from Straight Barriers, Reflection of Circular Waves from Various Barriers, Reflection of Waves from Concave Barriers, Refraction of Waves, Barrier Penetration by Waves, Bragg Reflection of Waves, Doppler Effect, Formation of Shock Waves, Superposition of Pulses, Interference of Waves, The Effect of Phase Differences Between Sources, Single Slit Diffraction of Waves, Multiple Slit Diffraction of Waves,* and *Diffraction and Scattering of Waves Around Obstacles;* and (c) Vector Kinematics Series (black-and-white): *The Velocity Vector, Velocity in Circular and Simple Harmonic Motion, The Acceleration Vector, The Velocity and Acceleration in Circular Motion, Velocity and Acceleration in Simple Harmonic Motion,* and *Velocity and Acceleration in Free Fall.*

Distributors (each offers the films in at least one of three formats— (1) 16mm reels, (2) 8mm reels, (3) 8mm Technicolor cartridges): Macalaster Scientific Corporation, McGraw-Hill Book Co., Modern Learning Aids, Science Electronics, The Ealing Corporation. Further information about the project may be obtained from Dr. Strickland.

289. Films on Superfluidity and Superconductivity. Alfred Leitner, Department of Physics, Michigan State University, East Lansing, Mich. 48824. (Present address: Department of Physics, Harvard University, Cambridge, Mass. 02138.) (1962–1966)

(a) *Liquid Helium II, The Superfluid.* The film demonstrates the following: the lambda-point transition; the viscosity paradox by the superleak versus the rotating cylinder methods; two experiments involving the fountain effect; the Rollin film; and second sound, whose speed is measured near 1.6°K. Narration builds the two-fluid model, for whose superfluid component the above experiments prove zero viscosity and entropy, and discusses the limitations of the model.

(b) *An Introduction to Superconductivity.* The film discusses, by narration and demonstration experiment: the disappearance of electrical resistance; the dependence of transition temperature on magnetic field; the Meissner effect; and the superconducting electron energy gap by the electron tunneling junction. The film is restricted to type I superconductivity and builds the now-accepted model of electrons bound to each other.

Both films are 16mm, black-and-white with sound. Script and explanatory comments are provided to purchasers. Film (a), released in June 1963, is 38 minutes in length. Film (b) is expected to be ready for release soon.

All inquiries on distribution should be sent to the distributor (Audio-Visual Center, Michigan State University); all technical inquires to the project director.

290. Short Films in Physics. *(Secondary, College)* Franklin Miller, Jr., Department of Physics, Kenyon College, Gambier, Ohio 43022. (1961–1963)

A series of 19 short, single-concept, live-action film clips has been produced, each clip about 3 minutes in length, designed to help physics teachers present essential concepts and demonstrations which are difficult or impossible to present otherwise in classroom or lecture hall. Using conventional 16mm projectors, or cartridge-type 8mm projectors, a teacher will be able to present concepts in a classroom situation of his own devising without breaking the thread of his presentation. All but one of the films *(Nonrecurrent Wavefronts)* are in color. Only the essential action is shown and the films are silent to allow a teacher to supply a commentary at the level of his own class. A teachers' guide furnished with each film gives data, calculations, theory, and interpretation. While primarily designed for college courses, most of the films will also be useful in secondary-school courses.

The film clip series includes the following subjects: *Radioactive Decay; Scintillation Spectrometry; Absorption Spectra; Ferromagnetic Domain Wall Motion; Paramagnetism of Liquid Oxygen; Critical Temperature; Single Slit; Double Slit; Resolving Power; Michelson Interferometer; Coupled Oscillators-Equal Masses; Coupled Oscillators-Unequal Masses; The Wilberforce Pendulum; Measurement of "G"—The Cavendish Experiment; Inertial Forces-Translational Acceleration; Inertial Forces-Centripetal Acceleration; Temperature Waves; Nonrecurrent Wavefronts; Tacoma Narrows Bridge Collapse.*

Production has been in 16mm and 8mm, on reels, and in 8mm cartridges for automatic projection. The films are sold, separately or in complete sets, by The Ealing Corp.; Cambosco Scientific Co.; The Macalaster Scientific Corp.; Welch Scientific Co.; Distribution Supervisor, Motion Picture Division, Ohio State University, 1885 Neil Avenue, Columbus, Ohio 43210; and Science Electronics.

291. Color Motion Pictures Illustrating Satellite

Motion, Gravitation, and Celestial Mechanics. *(Secondary, College)* HARRY F. MEINERS, Department of Physics, Rensselaer Polytechnic Institute, Troy, N.Y. 12181. (1959–1962)

Two films have been made using an electronic planetarium, with the aid of an optical multiplexing apparatus which allows the camera to record simultaneously and with an accurate time scale, the image of the orbit of a satellite and the image of a rotating colored relief model of the earth.

Satellite Orbits contains an analysis of the theory of gravitation, including a discussion of Kepler's laws, a detailed discussion of the elements of satellite motion, and actual scale orbits of some early artificial satellites.

Satellite Lifetime displays the three phases of orbital decay, discusses the exponential decrease in density of the atmosphere above the earth, and explains how satellites can be used as probes to estimate atmospheric density. The film also shows models of Vanguard I and II in orbit around the rotating earth and an actual satellite disintegrating as it enters the earth's atmosphere.

The films can be obtained from the Office of Institutional Research, Rensselaer Polytechnic Institute. Preview prints are available.

292. Films about Symmetry. JUDITH BREGMAN, Department of Physics, Polytechnic Institute of Brooklyn, Brooklyn, N.Y. 11201. (1966–1967)

The two films to be produced are designed to teach the principles of geometric symmetry to physics majors but are also expected to be useful in other physical science courses.

The first, a ten-minute animated film, will be cast in the form of semi-abstract human figures in continual motion; the arrangements and movements of the figures will display symmetries and by implication define various symmetry elements and show the consequences of combining two or more such elements. There will be no spoken narration; music will be used to produce the basic rhythmic timing of the movement and changes of its tone and quality will be used to accomplish some of the functions of a narrator. The film is designed to supplement lectures and will be accompanied by a booklet that will make explicit the information that the film presents implicitly.

The second film will be approximately 25 minutes in length and will employ more conventional teaching techniques against which the effectiveness of the new techniques of the first film can be judged. This second film will present the concept of symmetry and the range and variety of applications of this concept. Geometric, time, and color symmetries will be presented using examples from nature, the laboratory, models, and possibly stills from the first film.

Further information will be available from the project director.

293. Sourcebook for Demonstration Experiments in Physics. HARRY F. MEINERS and ROBERT RESNICK, Department of Physics, Rensselaer Polytechnic Institute, Troy, N.Y. 12181. (Grantee: American Association of Physics Teachers, 335 East 45th Street, New York, N.Y. 10017.) (1961–)

The aim of this project is to prepare a new reference text which will bring together the best demonstration equipment and techniques in physics now available. Rensselaer Polytechnic Institute serves as the coordinating center for this program of the American Association of Physics Teachers. The new book, to be entitled *A Reference Source for Demonstration Experiments in Physics,* will consist of descriptions of demonstration equipment including their use in lectures, photographs, lists and sources of materials and, where appropriate, working schematics to make possible construction by individuals. Emphasis in the selection of material is placed on demonstrations related to the fundamental concepts of contemporary physics, e.g., demonstrations of the conservation laws of energy, momentum, and angular momentum; of kinetic theory; of quantum effects such as the Franck-Hertz experiment and the diffraction of electrons; of the microscopic properties of solids, such as magnetic domains and the Hall effect; of scattering and resonance phenomena; of electric and magnetic field patterns; of wave phenomena; and of the velocity of light.

In addition, articles by the following authors will be invited: Sir Lawrence Bragg, "The Role and Purpose of Lecture Demonstrations in England as Illustrated by the Tradition at the Royal Institution"; Walter Eppenstein, "Overhead Projection"; Gerald J. Holton, "What is Conveyed by Demonstration? Some Reflections and Styles"; Everett M. Hafner, "Corridor Demonstrations"; Robert I. Hulsizer, "Films as a Lecture Aid"; Rosalie C. Hoyt, "Closed-Circuit Television"; Harry F. Meiners, "Stroboscopic Effects"; R. W. Pohl, "Shadow Projection"; Eric M. Rogers, "The Role and Purpose of Lecture Demonstrations in the United States"; and P. H. Scherrer, "The Role and Purpose of Lecture Demonstrations in Switzerland."

The two-volume reference work will be published by

The Ronald Press Company.

A brochure explaining all aspects of the program is available from Professor Meiners.

294. Lecture Demonstrations and Laboratory Exercises for Introductory College Physics. John M. Fowler, Department of Physics, Washington University, St. Louis. (Present address: Commission on College Physics, Physics and Astronomy Building, University of Michigan, Ann Arbor, Mich. 48104.) (1962–1964)

The project is developing the necessary auxiliary laboratory and lecture materials to accompany an introductory physics course designed for all beginning students. In the demonstrations, emphasis has been placed on systems which reproduce simple mathematical models and which can be presented with increasing sophistication during several lectures. Such demonstrations have been developed in the following subjects: frames of reference, collisions, harmonic motion, wave propagation in a one-dimensional medium, electron diffraction, Coulomb scattering, and charged particle motion in an electrostatic field.

During the latter part of the project the use of film techniques in demonstrations has been investigated, particulrly those techniques which use the unique properties of film to retard and advance time and to superimpose images. A pilot film superimposing a simple collision and the momentum-space representation of that collision has been made and was the subject of development at the recent Seattle workshop.

The laboratory experiments are designed to provide phenomenological support to the lectures, to introduce certain subjects independently, and to provide drill in data analysis, graphing, etc. Experiments include: conversion of kinetic energy to heat, diffraction photometry, force on a current, wave propagation in lumped media, and probability.

Rough film footage of Lenz's law demonstrations with a cyclotron magnet has been prepared and given to Educational Services Incorporated for refinement.

Complete descriptions of demonstrations will be given in the sourcebook in preparation at Rensselaer Polytechnic Institute (see Item 293). Shop drawings of the one-dimensional wave propagation demonstrations are available from the project director.

295. Laboratory Experiments in Physics. Ronald Geballe, Department of Physics, University of Washington, Seattle, Wash. 98105. (1963–1966)

Several undergraduate instructional experiments are being developed for both the introductory and the advanced levels. A senior physicist has been assigned to materialize, as instructional experiments, the ideas generated in the departmental research areas. For the advanced laboratory, an electron diffraction camera and optical pumping equipment have been completed, and an apparatus for the study of ion formation in gases is near completion. For the introductory laboratory, a versatile central-force experiment and an experiment on the energy and momentum of a transverse wave in a chain have been developed. Papers on the optical pumping experiment and the central-force experiment have been prepared, and one on the electron diffraction camera is in preparation. Shop drawings for the construction of each of the experiments will be available.

Experiments now in process of development include one on Rutherford scattering and another on the cosmic ray muon spectrum. Experiments planned for future work include second sound in liquid He-II, the Einstein-de Haas effect, and solid-state transport properties.

296. Experiments on Momentum: (A) Loss of Energy in Captive Collisions, (B) Falling Sand on Scale. *(Secondary, College)* T. N. Hatfield, Department of Physics, University of Houston, Houston, Tex. 77004. (1960–1962)

1. A 30-cm, rigid beam is mounted on a ball bearing at the center, allowing rotation in a vertical plane. Masses m are attached to each end of the beam. A third mass m (steel ball) is dropped from height h so as to be captured by the mass at one end of the beam while the beam is at rest in a horizontal position. Energy loss is measured by determining the minimum value of h to cause a complete revolution. The rigid beam may be replaced by a flexible beam of spring steel for inelastic collisions.

2. The apparatus to show momentum principles involved in sand falling on a scale is somewhat like that demonstrated by Dr. Paul Whiting in the apparatus contest at the 1961 AAPT meeting. However, the apparatus described here shows the transient as well as the steady state. A high, mechanical-optical magnification of the change of force produces a vertical motion of a focused beam on a screen or wall for lecture demonstration. Simultaneous rotation about a vertical axis gives a horizontal motion of the spot of light with time. The apparatus is completely mechanical-optical, except for a magnetic trap door for dropping the sand.

A complete report containing detailed descriptions, drawings, and photographs of the apparatus, can be obtained from the project director.

297. Experiments and Demonstrations for General Physics. GUENTER SCHWARZ, Department of Physics, Florida State University, Tallahassee, Fla. 32306. (1962–1964)

Demonstrations developed included: (1) Rowland's experiment on the magnetic equivalence of a current and a moving charge, and (2) the energy distriubtion of electrons from a hot wire. Experiments are concerned primarily with these phenomena and with additional experiments such as a nuclear scattering analog, the conservation of mechanical energy in a non-linear system, and equipment for describing Newton's second law for linear and circular motion.

Further information can be obtained from the project director.

298. Laboratory Demonstrations and Experiments in Optics. JOHN STRONG, Laboratory of Astrophysics and Physical Meteorology, The Johns Hopkins University, Baltimore, Md. 21218. (1959–1963)

A manual describing suitable student experiments in optics was prepared to satisfy the needs of both the small colleges and the larger institutions. The manual (*Optics: Experiments and Demonstrations*, by C. Harvey Palmer, The Johns Hopkins Press) contains 59 experiments described under the general headings of (1) ray optics, (2) wave optics, (3) polarization and crystal optics, and (4) spectroscopy. Each of the experiments in the manual contains references, some theory, drawings and a description of the apparatus set-up, and procedures. In August 1962 a copy of the manual was sent, free of charge, to the head of the physics department of all colleges and junior colleges in the United States. Additional copies can be purchased from The Johns Hopkins Press.

299. Study of the Teaching of the Physics of Fluids in American Universities. RAYMOND J. EMRICH, Department of Physics, Lehigh University, Bethlehem, Pa. 18015. (Grantee: The American Institute of Physics, 335 East 45th Street, New York, N.Y. 10017.) (1965–1966)

Textbooks will be reviewed; physicists, active in the teaching of fluid mechanics, will be interviewed; and an extensive correspondence program will be initiated to assess present practice in the teaching of the physics of fluids and to note effective ways of presenting fluid dynamics topics. A report of the initial survey will be circulated to selected physicists, who are either working in the area or who have broad education interests, to ascertain the extent to which present practice matches their concept of the role of the physics of fluids in undergraduate and graduate curricula. A final report will describe the findings and offer suggestions to departments wishing to increase the emphasis placed on the physics of fluids.

300. Apparatus for Advanced Undergraduate Physics Laboratory. THOMAS H. WOOD, Department of Physics, University of Pennsylvania, Philadelphia, Pa. 19104. (1963–1964)

The objective is to design and develop experiments and the necessary equipment in order to provide the advanced undergraduate with a direct measurement of the black-body distribution law. A secondary objective will illustrate the physical nature of optical resonance permitting a rough determination of atomic half-lives of excited states in several alkali metals. Reasonably priced instrumentation, readily available, will be used wherever possible. For the first purpose, a simple Ebert-type prism spectrometer has been designed which operates in the near infrared; construction of the instrument is almost completed. For the second purpose, a technique has been developed for the construction of optical resonance sources which are both reliable and easy to prepare.

301. Atomic and Nuclear Experiments for Undergraduate Laboratories. GEORGE E. BRADLEY and JACOB DEWITT, Department of Physics, Western Michigan University, Kalamazoo, Mich. 49001. (1961–1963)

Several experiments are being developed for use in the area of atomic and nuclear physics. One experiment involves the alignment of sodium or rubidium atoms by resonance absorption of circularly polarized D-line radiation (optical pumping), and the measurement of nuclear magnetic moments. The aligned atoms in vapor state are excited by a radio-frequency magnetic field. When the frequency corresponding to a Zeeman transition is applied, the orientation is destroyed and transmission of the aligning light is reduced. Necessary equipment will be designed for the experiment.

Another experiment involves basic absorption and scattering studies with alpha, beta, and gamma radiation. The equipment will include the use of small Geiger tubes to measure scattering. Studies of ions in magnetic fields at low pressures will also be made.

Further information can be obtained from Dr. Bradley.

302. Mössbauer-Effect Experiments for Advanced Physics Laboratories. J. Richard Haskins, Department of Physics, Gettysburg College, Gettysburg, Pa. 17325. (1961–1962)

Equipment demonstrating the Mössbauer effect has been developed for use by students in advanced undergraduate laboratory courses in modern physics. One experiment used Fe ^{57} as source and absorber, and a loudspeaker with audio-oscillator and oscilloscope as detector. The second experiment utilizes a toy train car on a slightly inclined track driven by a micrometer screw. Sources can be prepared by evaporating Co ^{57} on copper and iron foils and annealing in vacuum at about 920°C. in a small commercial furnace. The student experiments use an enriched absorber foil which is available commercially, as are all the items needed for these experiments. No AEC license is required. Expenditures of $650 to $1,050 are required to set up these experiments.

A final report can be otbained from the project director.

303. Experiments in Optics Using the Optical Maser. Robert E. Hopkins and M. Parker Givens, Institute of Optics, University of Rochester, Rochester, N.Y. 14627. (1962–1965)

The purpose of this project is to develop experiments and lecture demonstrations appropriate to introductory and intermediate courses in physical optics, using the optical maser as a light source. With the gas laser it is possible to obtain, in a diffraction-limited, collimated beam, about 10^4 times more luminous flux than can be obtained from a large conventional monochromatic source. This allows direct projection of many optical effects and eliminates tedious microscopic observation.

Among the topics dealt with are: (1) aperture diffraction and aberration effects in lens systems, (2) Abbé theory of the microscope and the illustration of phase contrast, (3) a simple type of interferometer, (4) properties of the ruby rod maser, (5) the velocity of light, (6) properties of Fabry-Perot interferometers, (7) heterodyning techniques for spectral analysis, and (8) shearing interferometry.

Further information can be obtained from the project director.

304. Overhead Projector Demonstrations in Physics. Walter Eppenstein, Department of Physics, Rensselaer Polytechnic Institute, Troy, N.Y. 12181. (1959–1961)

Four groups of accessories for overhead projectors have been designed and constructed for use in physics lectures presented to large groups of students.

1. *Overlays.* A series of overlays has been prepared consisting of single transparencies, colored overlays (usually four to six per transparency), movable overlays, and "technamated" overlays for use with a polaroid spinner. The transparencies are diazotype reproductions from an ammonia-developing process.

2. *Models.* Motorized and non-motorized models made of lucite include: demonstrations of simple harmonic motion, wave phenomena and super-position, cyclotron model, AC generator, primary and secondary coils, kinetic theory, vector addition, and probability board. Collision and scattering phenomena are demonstrated by rolling steel balls dipped in colored inks across the projector, leaving visible tracks of various colors. Rutherford scattering and the Compton effect can also be demonstrated with these devices.

3. *Breadboards for Electrical Connections.* A transparent breadboard has been constructed for electrical connections. On this flexible board, many circuits have been set up using miniature batteries, switches, etc. Actual current and voltage measurements are made by projection meters mounted on the overhead projector. A circuit diagram is projected first; the actual circuit is then superimposed. This technique has been used in discussion of electrical circuits involving resistors as well as thermistors, using d.c. and a.c. When a permanent magnet is included, the Hall effect can be demonstrated directly on the overhead projector. The time constant for the charge and discharge of a capacitor can also be measured easily. This project was awarded first prize at the Apparatus Competition of the American Association of Physics Teachers in 1961.

4. *X-Y Plotter.* An X-Y plotter and associated circuits have been completed. This recorder plots on the stage of an overhead projector any signal from suitable amplifiers, analog computers, etc.

A detailed report entitled "The Overhead Projector in the Physics Lecture," is available for $1.00 from the Rensselaer Union Supply Store, Rensselaer Polytechnic Institute.

305. Simple Vacuum Techniques and Experiments. R. Norman Peacock, Coordinated Science Laboratory and Department of Physics, University of Illinois, Urbana, Ill. 61803. (1965–1966)

The purpose of this project is to develop simple methods of building vacuum systems that can be used by students in advanced undergraduate laboratories and to devise suitable experiments in the fields of vacuum and surface physics and electronics. Modern vacuum principles are to be emphasized.

Two types of construction are used. The first, usually called "solder-glass," uses the methods developed by J. H. Owen Harries and the Science Teaching Center at the Massachusetts Institute of Technology. It is best suited to making small permanently sealed tubes. Another and very versatile procedure is the construction of vacuum systems from standard flanged Pyrex Components as sold by the Corning Glass Works. These are available in a very wide range of shapes and sizes at reasonable cost and may be quickly assembled erector-set fashion to make pumped systems capable of pressures at least as low as 10^{-6} Torr.

Expriments ready for use in the advanced undergraduate laboratory include: (1) a diffusion-pumped flanged Pyrex system for studying electrostatic and magnetic focusing of an electron beam; (2) components to permit conversion of the above pumping system to a vacuum gauge comparison and calibration unit; (3) a solder-glass experiment with a tube containing thermocouple and ionization gauges, in which the pressure may be varied from 10^{-2} Torr to 10^{-7} Torr by sorption pumping; and (4) experiments on gettering and ion pumping performed in solder-glass tubes.

Information concerning the experiments, details of the techniques, and photographs of some of the equipment are available from the project director.

306. Use of Semiconductor Particle Detectors in Magnetic Deflection Beta Particle Spectrometers.

DONALD E. OLSON, Department of Physics, University of Minnesota, Duluth, Minn. 55812. (1962–1963)

A semiconductor particle detector is used in a small, semicircular magnetic deflection spectrometer. A charge-sensitive, transistorized preamplifier was built to drive a scaler or ratemeter with a 25-mv input sensitivity. The preamplifier is a modified version of one designed at the Brookhaven Laboratory by R. L. Chase, *IRE Transactions*, N.S. (8), 147 (1961). The feedback is adjusted to give a voltage gain of about 1200 for the detection of beta particles. For alpha particle pulse-height measurements a more linear response is required, and a voltage gain of around 700 has worked well. The preamplifier has been used to drive a single-channel pulse height analyzer. The 4.52, 4.79, and 4.87 Mev alpha particle of Np^{237} were resolved (FWHM) of 140 kev is realized).

Surplus magnetron magnets are used with mild steel (10/10 hot rolled) pole faces to produce magnetic fields, 64 in.^{2} in area, 1¼″ air gap, of 500 to 3000 gauss. Horseshoe-shaped magnets from 5 to 25 lbs. in weight are added or removed to give the desired magnetic field intensity. A vacuum of 0.5 Torr is readily realized in an aluminum spectrometer chamber lined with lucite. A line source (Ba^{137}, 0.4mm wide and 6mm long) is drawn across the diameter of the particle paths and the K and L internal conversion electron lines of Ba^{137} are readily resolved.

A complete report on the work is available from the project director.

307. Optical Pumping Apparatus for Hyperfine Zeeman Transitions.

REUBEN BENUMOF, Science Department, Staten Island Community College, Staten Island, N.Y. 10301. (1963–1964)

The purpose of this project is to develop optical pumping apparatus and experiments for the study of hyperfine Zeeman transitions. The equipment is intended for use in undergraduate courses in atomic physics and intermediate laboratory courses. An attempt will be made to devise less expensive methods of producing the desired effects. Suitable experiments will be developed and tested in the classroom.

A general description of research done in this field is given by R. Benumof in an article entitled "Optical Pumping Theory and Experiments," *American Journal of Physics* 33, 2 (1965).

308. Microwave Spectroscopy Experiment.

JOHN J. FARIS, Department of Physics, Colorado State University, Fort Collins, Colo. 80501. (1962–1965)

The project has developed apparatus suitable for upper-division, undergraduate laboratory study of the microwave spectrum of ammonia.

The apparatus consists of an absorption cell and allied equipment designed to operate at 23 - 25 kmc in order to study the microwave spectrum of ammonia. The cell is provided with a Stark electrode, so that the Stark effect in the spectrum can be studied.

Further information can be obtained from the project director.

309. An Undergraduate Stern-Gerlach Apparatus.

MELVIN DAYBELL, Department of Physics, New Mexico State University, University Park, N. Mex. 88070. (1963–1966)

The objective is to develop an inexpensive apparatus for performing the Stern-Gerlach experiment on the quantization of atomic spins. The design will utilize parts of existing apparatus developed by the Apparatus Drawings Project of the American Institute of Physics and the American Association of Physics Teachers, as well as components built specifically for the present experiment. Some components, such as magnet vacuum system, and an electrometer will be interchangeable with other teaching and/or research apparatus. All work to date has been done using a potassium beam and a hot wire detector. The apparatus will be useful for direct demonstrations of quantum effects as well as in the teaching of atomic and molecular beam technique. If produced on a commercial basis, in kit form, as an accessory for the Ealing Caltech magnet, the apparatus should cost under $200, exclusive of the magnet, magnet power supply, electrometer, and a source of high vacuum.

Further information is available from the project director.

310. Versatile Nuclear Coincidence Apparatus for Undergraduate Use. E. JOHN WINHOLD, Department of Physics, Rensselaer Polytechnic Institute, Troy, N.Y. 12181. (1962–1963)

The objective was to design and develop a prototype, nuclear coincidence apparatus which would be versatile, simple to operate, and modest in cost. The apparatus is intended for use in advanced undergraduate physics laboratories. It utilizes scintillation counters together with transistor electronics embodying simplified circuitry and construction. Differential pulse height analysis is provided in both counter channels. The apparatus is applicable to a study of such topics as gamma ray scintillation spectrometry measurements, positron annihilation, angular correlation measurements, lifetime of isomeric states, and the Compton effect.

A detailed report is available from the project director.

311. Apparatus for Demonstrating Simple Harmonic, Circular and Vibratory Motion. *(Secondary, College)*, MORRIS B. ABRAMSON, Physical Science Department, Flushing High School, Flushing N.Y. 11354. (Grantee: Queens College, Flushing, N.Y. 11367). (1960–1961)

The apparatus consists of three units which can be used separately or in combination to illustrate simple harmonic, circular, and vibratory motion and their interrelationships. Adjustments can be made to illustrate frequency, amplitude, wavelength, clamping, and resonance. A recording unit traces out an appropriate sine wave representing the motion. Local construction of the equipment is possible with costs estimated at $150–$200.

Further information is available from the project director.

312. An Electron-Optical Bench for Student Experiments. HENRY E. BREED, Department of Physics, Rensselaer Polytechnic Institute, Troy, N.Y. 12181. (1961–1963)

An electron beam instrument, suitable for student construction and experimentation, has been designed. The basic components include a vacuum system, a high voltage source, an electron gun, and an electron optical assembly with housing. The vacuum gauge circuits, high voltage source, and the electron optics are designed for local construction. The vacuum gauge circuit and high voltage source may also be purchased from any of several vendors. The electron guns are of the type readily available in the TV-tube reconstruction industry. The housing is made from commonly available copper plumbing fittings. A small vacuum system capable of 10^{-6} Torr is required.

An illustrated booklet is available from the project director.

313. Vacuum Chambers for Nuclear Physics Experiments. ARTHUR W. WALTNER, Department of Physics, North Carolina State of the University of North Carolina, Raleigh, N.C. 27607. (1963–1965)

The objective of the project is to design and construct suitable vacuum chambers for performing experiments employing commercialy available semiconductor detectors. Experiments utilizing these chambers for measurements in alpha-particle, beta-particle, conversion electron, and gamma-ray spectrometry, and nuclear reactions will be devised and tested.

The following materials will soon be available: (1) drawings of typical chambers, (2) block diagrams for typical counting circuits, (3) experiment write-up sheets, and (4) typical data for each experiment.

314. Spark Chambers. ALLAN M. SACHS, Department of Physics, Columbia University, New York, N.Y. 10027. (1962–1965)

In order to demonstrate cosmic radiation and the bending of beta-rays (from a radioactive source) in a magnetic field, two types of spark chambers and a single simplified circuit for pulsing the chambers have been constructed. One chamber consists of 6 to 12 flat metallic plates spaced ¼-inch apart. When a cosmic ray particle passes through the chamber, it is detected by two scintillation counters and alternate plates of the chamber are pulsed to a high potential. The resultant sparks, which occur in each gap along the path of the cosmic ray, are very bright and can be observed by students in a large lecture room.

The second chamber has a single gap and one of the plates is made of transparent mesh. Beta particles from a strontium-90 source pass in and out of the chamber through the thin windows in the sides and travel parallel to the plates. A continuous curtain of discharge, following the path of the particle, is observed through the mesh. Curvature of the tracks is observed when a magnetic field is provided by a pair of Helmholtz coils.

A paper giving details of construction is being prepared for publication and preprints will be available from the project director.

315. Basic Spectrometer. JOHN W. DEWDNEY, Department of Physics, University of New Hampshire, Durham, N.H. 03824. (Former grantee: Dartmouth College, Hanover, N.H. 03755.) (1960–1962)

A mass spectrometer has been designed around simple constituents: the vacuum system is made from copper plumbing parts; electrical leads into the vacuum are via darning needles pushed through rubber stoppers; the filament of the thermal ionization source is from a small light bulb; object and image slits are made from bits of razor blades sandwiched between brass washers,

The magnetic field is suppled by a permanent magnet fitted with homemade cylindrical pole pieces (of such a diameter to give second-order direction focusing). A modest vacuum of 10^{-4}mm Hg is required. When the instrument is focused (by adjusting the position of the pole pieces) and aligned (by rotating greased-rubber stoppers) a resolving power of 50 can be obtained.

The cost of components for the instrument proper (not including a permanent magnet or electrical and vacuum equipment) is something under $5. While a lathe is required for making two cylindrical pole pieces for the magnet, other construction requires only common hand tools.

For additional detail, see: John W. Dewdney, "Poor Man's Mass Spectrometer," *American Journal of Physics* 31, 932 (1963).

316. Apparatus for Measuring Relativistic Change of Mass and Momentum Spectra of Electrons from Beta Ray Sources. MALCOLM CORRELL and ALBERT A. BARTLETT, Department of Physics, University of Colorado, Boulder, Colo. 80304. (1962–1963)

An instructional apparatus for measuring e/m of beta particles as a function of velocity has been designed and constructed. A 10-mc source such as Sr^{90} or Cs^{137} provides electrons with a wide range of speeds. A magnetic field momentum selector and a crossed magnetic and electric field velocity selector separate out electrons which are detected by a G-M or solid-state counter. The same magnetic field is used in both selectors and produced by an inside-out electromagnet, which may be described as an iron pillbox with the energizing coil on the inside. The pillbox also serves as the vacuum chamber.

Design and details of use, together with results obtained, are given in "An Undergraduate Laboratory Apparatus for Measuring e/m as a Function of Velocity, I," A. A. Bartlett and Malcolm Correll, *American Journal of Physics* 33, 327 (1965).

By relocating some of the elements one can also use the apparatus as a beta-ray spectrometer. The work is being pursued and early publication is anticipated. Further information can be obtained from the project directors.

317. Apparatus for Measuring Relativistic Variation in Mass of Electrons. JOHN W. DEWDNEY, Department of Physics, University of New Hampshire, Durham, N.H. 03824. (Former grantee: Dartmouth College.) (1964–1965)

Apparatus is being developed which, it is expected, will make possible the measurement of a relativistic effect in electrons accelerated to energies up to 30 Kev. The electrons are deflected in a transverse electrostatic field whose magnitude is made proportional to the accelerating field. A change in the deflection as the accelerating voltage is increased is a measure of the *difference* between relativistic behavior and nonrelativistic behavior. An article will be published, probably in the *American Journal of Physics*, in 1966.

L. Psychology

For additional projects related to this section see also:

80. Memo-Activity Camera.

120. Student Laboratory Equipment in Visual Science.

318. Filmed Teaching Interviews with Outstanding Contributors to Psychology. RICHARD I. EVANS, Department of Psychology, University of Houston, Houston, Tex. 77004. (1963–1965)

Under terms of a grant from the Fund for the Advancement of Education, this project was launched on the premise that filmed interviews with outstanding contributors to theory in the psychology of personality would add important dimensions to education in this field. Such films would also have archival significance and provide a model of how this unique use of the dialogue could be employed as course content in other scientific disciplines.

Four one-hour, black-and-white, 16mm sound films of interviews with the late Carl Jung, and one 45-minute, black-and-white, 16mm sound film are available from the University of Houston Film Production Center. Also, one 30-minute, black-and-white, 16mm sound film entitled *Jung Speaks of Freud* is available from Psychological Cinema Register, Pennsylvania State University, University Park, Pa. A moderate rental fee is charged.

The present project is continuing the series of interviews with other leading behavioral scientists. The questions posed by the interviewer allow the interviewee to compare his conceptualizations with other approaches to the psychology of personality, to develop the key concepts in his theory, and to speculate on such things as future developments in the field of personality theory. Members of the advisory committee to the project are Dr. Gardner Murphy of the Menninger Foundation and Drs. Ernest J. Hilgard and Nevitt Sanford of Stanford University.

Films produced by this project will be made available to educational institutions throughout the world. Dialogues will be published in book form as were the Jung and Jones interviews: *Conversations with Carl Jung and Reactions from Ernest Jones,* D. Van Nostrand Co., Princeton, N. J. (1964) and *Conversations with Erich Fromm* (selection of publisher pending). The twelve films (30 to 50 minutes, black-and-white, 16mm sound prints) now being produced include interviews with Erich Fromm, B. F. Skinner, Gordon Allport, Henry Murray, Raymond Cattell, Erick Erikson, and Gardner Murphy.

A summary report entitled, "Filmed Teaching Interviews with Notable Contributions to Psychology: A New Social Psychological Dimension in Course Content Improvement," may be obtained from the project director.

319. Focus on Behavior. *(Secondary, College)* ARTHUR G. BRAYFIELD, American Psychological Association, 1200 Seventeenth Street, N.W., Washington, D.C. 20036, and ROBERT B. HUDSON, National Educational Television and Radio Center, 10 Columbus Circle, New York, N.Y. 10019. (Grantee: American Psychological Association.) (1961–1963)

The ten films (16mm, black-and-white, sound, 30 min.) present current research in experimental psychology which reveals significant concepts, methods, and new advances in the scientific study of behavior. Titles and the principal scientists involved are:

The Conscience of a Child (Growth and Development), Robert Sears; *A World to Perceive* (Perception), Herman Witkin, Eleanor Gibson, and Richard D. Walk; *The Brain and Behavior* (The Brain and the Nervous System), Donald B. Lindsley and Horace W. Magoun; *The Chemistry of Behavior* (Psychopharmacology), Roger Russell, and Sebastian Grossman; *Learning About Learning* (Learning Research), Howard Kendler, Tracy Kendler, Kenneth Spence, Harry Harlow, and B. F. Skinner; *No Two Alike* (Individual Differences and Psychological Testing), Lloyd Humphreys and James Gallagher; *The Social Animal* (Social Psychology), Stanley Schachter, Leon Festinger, and Morton Deutsch; *The Need to Achieve* (Motivation and Personality), David McClelland; *Of Man and Machines* (Engineering Psychology), Paul Fitts, Julian Christiansen, and George Briggs; *Computers and Human Behavior* (Computers and Human Mental Processes), Bert Green, Herbert Simon, and Allan Newell.

The series of films was shown on more than 90 educational television stations affiliated with National Educational Television. The films are available from N.E.T. Film Service, Audio-Visual Center, Indiana University, Bloomington, Ind. 47405. To obtain a brochure with study guides write National Educational Television and Radio Center in New York City.

320. Study of the Undergraduate Curriculum in Psychology. W. J. MCKEACHIE and J. E. MILHOLLAND, Department of Psychology, University of Michigan, Ann Arbor, Mich. 48103. (1959–1961)

The first phase of this study was a questionnaire survey of all the degree-granting departments of psychology in the country, carried out during the academic year 1959–60. This survey attempted to acertain the extent to which the curriculum proposed in *Improving Undergraduate Instruction in Psychology* (D. Wolfle et al., Macmillan, 1952) had been put into practice and to solicit opinions of its value.

The second phase was an 8-week conference at Ann Arbor during the summer of 1960. The chapters in the published report of the conference include: "Experiences with the Wolfle Curriculum," "Pressures on the Curriculum," "Preprofessional and Vocational

Training," "The Beginning Course," "The Experimental-Statistical Area," "Three Model Curricula for the Major," "Suggestions for Research," and "Annotated Bibliography."

W. J. McKeachie and J. E. Milholland, *Undergraduate Curricula in Psychology: Report of the Michigan Conference* (Scott, Foresman and Co., 1961).

321. Experiments on Animal Behavior. RICHARD M. KLEIN, Department of Psychology, Adelphi University, Garden City, Long Island, N.Y. 11530. (1962–1963)

The purpose of this project was to develop some fifteen experiments on fish behavior to illustrate principles of learning and motivation. The experiments can be performed by undergraduate psychology or biology students as part of a demonstration program on learning. The experiments are suitable for courses in the psychology of learning and motivation. Illustrated were such principles as acquisition, extinction, reinforcement magnitude, partial reinforcement, secondary reinforcement, chaining escape, avoidance, drive, generalization, discrimination, delay of reinforcement, conflict, classical conditioning, and probability learning. The apparatus consisted of various maze types (for discrete trials) and manipulanda set-ups.

Further information can be obtained from the project director.

322. Psycho-Biological Apparatus for Demonstration and Student Research. *(Secondary, College)* D. K. CANDLAND, Department of Psychology, Bucknell University, Lewisburg, Pa. 17837. (1961–1962)

The apparatus is designed to provide compact, inexpensive, and flexible units for classroom demonstration and student research. All units may be built with household tools from materials purchased for under $5. The units include: a galvanometer for measuring the galvanic skin response, an algesiometer, a techistoscope, a light source for the demonstration of visual phenomena and psychological methods, mirror tracing, non-electric maze, rotating trapezoid, small-animal test chamber, and human maze or problem-solving apparatus.

A brochure containing descriptions and plans of the apparatus has been prepared, but is now out of print. Information on similar apparatus can be obtained from Louis Snellgrove, Union University, Jackson, Tenn. 38302.

323. Projection Color-Mixer. *(Secondary, College)* LORRIN A. RIGGS, Department of Psychology, Brown University, Providence, R.I. 02912. (1961–1962)

A portable instrument for projecting color test patterns on a screen has been constructed from standard, commercially available equipment. The device is suitable for group use in classes at the high school or college level to demonstrate the principal facts of color mixing. In addition, it can be used as an anomaloscope to detect, measure the severity, and classify the various types of color blindness. A pilot model of the device costs $85; a model using somewhat more powerful projectors costs $135.

L. A. Riggs, "A Projection Color Mixer," reprinted from *The American Journal of Psychology* (March 1964). Reprints are available from the project director.

324. Inexpensive Device for Demonstrations and Laboratory Measurements in Audition. NEIL R. BARTLETT, Department of Psychology, University of Arizona, Tucson, Ariz. 85721. (1961)

The device is intended for use in college courses in beginning psychology and physiology. Through appropriate matching of an audio oscillator, audio amplifier, speakers, and switches, the device performs throughout the audible frequency range at amplitudes from -10 to 50 db. Both frequency and amplitude are continuously variable. In addition, the usual step switches for frequency and amplitude and dual air conduction earphones are included so that the device can be used as a clinical audiometer for testing hearing. In this capacity, the device can be used in student research projects in beginning physiology and experimental psychology courses. The unit is housed in an attractive, sloping panel, metal cabinet with output jacks for the earphones and speakers. The speakers and crossover network are contained in a separate wooden enclosure. The entire unit is expected to cost under $200 and may be constructed by anyone with circuit wiring experience.

A final report with construction details and wiring diagrams can be obtained from Dr. Albert E. Bartz, Department of Psychology, Concordia College, Moorhead, Minn. 56560.

M. Sociology

For additional projects related to this section see also:

67. Social Science Program.
69. Sociological Resources for Secondary Schools.
89. Films on Nepalese Culture for Courses in Anthropology.

325. Behavioral Science Data Cards and Research Exercises. ROBERT SOKOL, Department of Sociology, Dartmouth College, Hanover, N. H. 03755. (1963–1965)

The objective of this project is to develop a technique for facilitating research or laboratory experience for students in introductory sociology courses. Students were given data from various professional studies, such as opinion-behavior surveys, demographic-ecological studies, ethnographic studies, experiments in social psychology, and cross-national statistics. Selected data from these studies were transferred to edge-punched "data cards," a set of which students analyzed in a series of twelve exercises. The content of the data cards and the exercises are keyed to representative concepts, such as socialization, primary relationships, status and class difference, alienation and juvenile delinquency, differential fertility, etc. Exercises are generally organized so that students not only replicate the original studies, but also use the data creatively by making predictions, deciding on control variables, and making *ex post facto* interpretations.

The educational objective of direct handling of professionally collected data by undergraduates is to provide experience with primary source material. Ideally, this should lead to a more meaningful understanding of sociology, to a more realistic appreciation of the current limitations in social research, and, most important, to a recognition of the significance of the scientific method in understanding human behavior. An extensive evaluation program is being conducted to appraise the merit of the materials.

A limited number of copies of the data cards, the laboratory assignments, and the evaluation report may be obtained from the project director. A laboratory manual for introductory sociology utilizing the data card technique will be published in 1966.

Appendix

List of Commercial Publishers, Film and Television Producers, and Apparatus Manufacturers Cited in Project Descriptions in this Publication

Academic Press, 111 Fifth Ave., New York, N. Y. 10003.
Addison-Wesley Publishing Co., Inc., Reading, Mass. 01867.
Ann Arbor Instrument Works, 1200 Rosewood, Ann Arbor, Mich. 48104.
A. R. F. Products, Inc., P. O. Box 75, Raton, N. Mex. 87740.
Association Films, Inc., 347 Madison Ave., New York, N. Y. 10017.
Blaisdell Publishing Co., 501 Madison Ave., New York, N. Y. 10022.
Cambosco Scientific Co., 342 Western Ave., Boston, Mass., 02135.
Chemical Education Publishing Co., 20th and Northampton Sts., Easton, Pa. 18042.
Central Scientific Co., 1700 Irving Park Rd., Chicago, Ill. 60613.
Clay-Adams, Inc., 141 East 25th St., New York, N. Y. 10010.
Doubleday and Co., Inc., 501 Franklin Ave., Garden City, N. Y. 11530.
E. P. Dutton and Co., Inc., 201 Park Ave., S., New York, N. Y. 10003.
The Ealing Corp., 2225 Massachusetts Ave., Cambridge, Mass. 02140.
Educational Testing Service, Princeton, N. J. 08540
Encyclopaedia Britannica Films, Inc., 1150 Wilmette Ave., Wilmette, Ill. 60091.
Forma Company, 111 East Northfield Church Rd., Whitmore Lake, Mich. 48189.
W. H. Freeman and Co, 660 Market St., San Francisco, Calif. 94104.
Gauthier-Villars, 55, Quai des Grands-Augustins, Paris (6e), France.
Harcourt Brace & World Co., 757 Third Ave., New York, N. Y. 10017.
Harvard University Press, Cambridge, Mass. 02138.
D. C. Heath and Co., 285 Columbus Ave., Boston, Mass. 02116.
The Heath Company, Benton Harbor, Mich. 49022.
Holden-Day, Inc., 728 Montgomery St., San Francisco, Calif. 94111.
Holt, Rinehart & Winston, Inc., 383 Madison Ave., New York, N. Y 10017.
Houghton Mifflin Co., 2 Park St., Boston, Mass. 02107.
The Jonhs Hopkins Press, Baltimore, Md. 21218.
McGraw-Hill Book Co., Inc., 330 West 42nd St., New York, N. Y. 10036.
Macalaster Scientific Corp., 60 Arsenal St., Watertown, Mass. 02172.
Macro Models, P. O. Box 287, South San Francisco, Calif. 94082.
The Macmillan Co., 60 Fifth Ave., New York, N. Y. 10011.
Modern Learning Aids, 3 East 54th St., New York, N. Y. 10022.
National Educational Television and Radio Center, 10 Columbus Circle, New York, N. Y. 10019.
Norwood Studios, 926 New Jersey Ave., N.W., Washington, D.C. 20001.
Philco Techrep Division, 515 Pennsylvania Ave., Fort Washington, Pa. 19034.
Plenum Press, Inc., 227 West 17th St., New York, N. Y. 10011.
Prentice-Hall, Inc., Englewood Cliffs, N. J. 07631.
Psychological Corp., 304 East 45th St., New York, N. Y. 10017.
Radiant Films, Inc., 247 West 42nd St., New York, N. Y. 10036.
Rand McNally & Co., P. O. Box 7600, Chicago, Ill. 60680.
Random House, Inc., 239 Great Neck Rd., Great Neck, N. Y. 11021.
Rinco Instrument Co., Greenville, Ill. 62246.
The Ronald Press Co., 15 East 26th St., New York, N. Y. 10010.
Science Electronics, Inc., Simon and Ledge Sts., Nashua, N. H. 03060.
Scott, Foresman & Co., 433 East Erie St., Chicago, Ill. 60611.
L. W. Singer Co., Inc., 249-259 West Erie Blvd., Syracuse, N. Y. 13202.
Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
Thorne Films, Inc., 1299 University Ave., Boulder, Colo. 80302.
University of California Press, Berkeley, Calif. 94720.
University of Chicago Press, 5750 Ellis Ave., Chicago, Ill. 60637.
University Tutorial Press, Ltd., Clifton House, Euston Rd., London, N.W. 1, England.
D. Van Nostrand Co., Inc., Princeton, N. J. 08540.
A. C. Vroman, Inc., 367 South Pasadena Ave., Pasadena, Calif. 91105.
W. M. Welch Scientific Co., 1515 Sedgwick St.. Chicago, Ill. 60610.
John Wiley & Sons, Inc., 605 Third Ave., New York, N. Y. 10016.
Yale University Press, 92-A Yale Station, New Haven, Conn. 06520.

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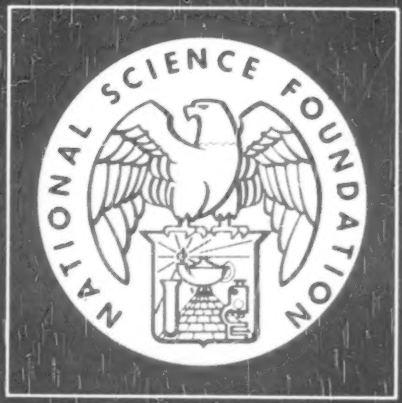
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